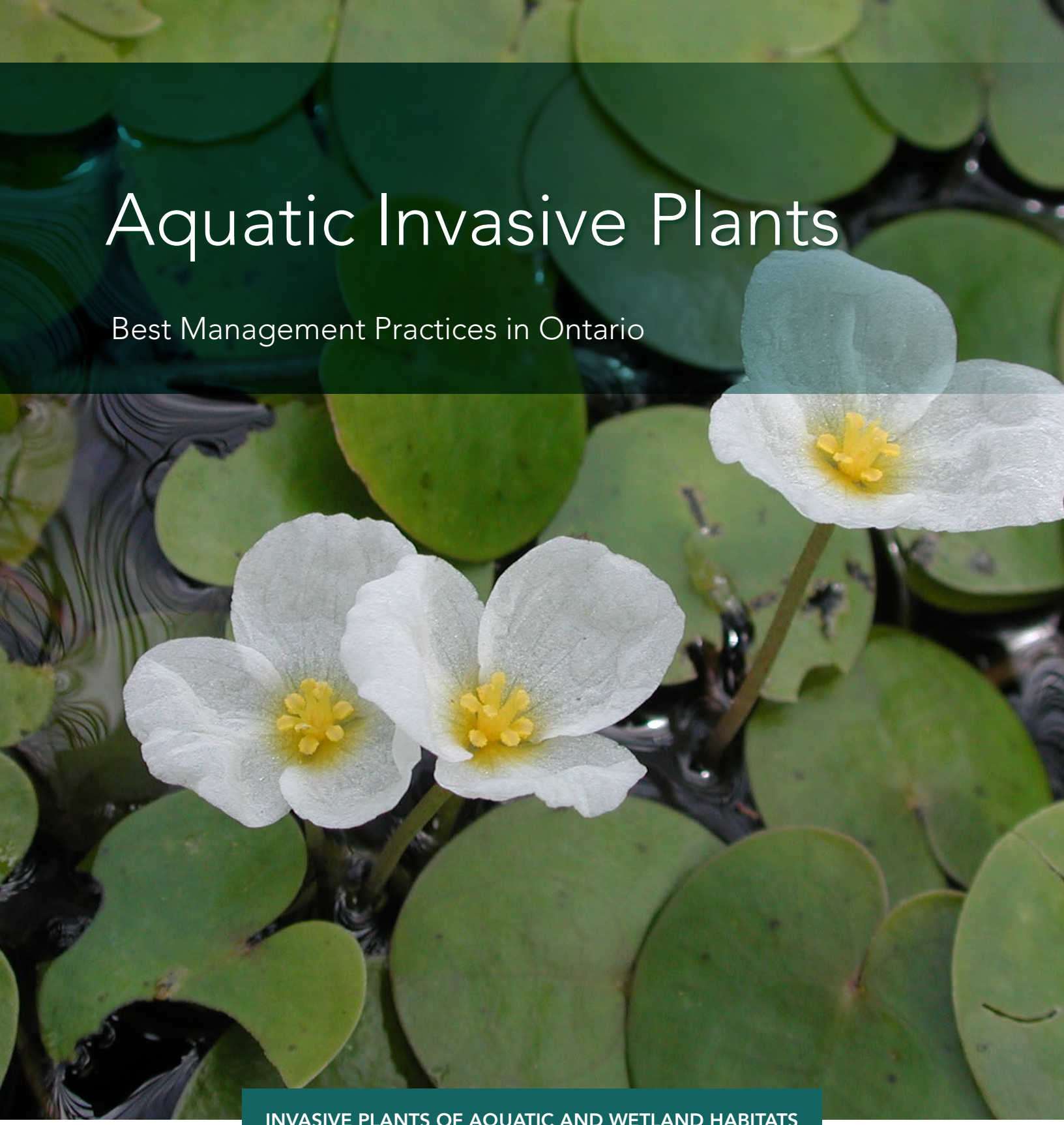

Aquatic Invasive Plants

Best Management Practices in Ontario

INVASIVE PLANTS OF AQUATIC AND WETLAND HABITATS

ontario.ca/invasivespecies

Ontario

ONTARIO INVASIVE PLANT COUNCIL

Foreword

Aquatic Invasive Plants: Best Management Practices in Ontario (BMPs) was developed to provide a useful tool towards efforts to control and manage invasive plants of aquatic and wetland habitats. The intent of this document is to relay information specifically related to control practices that have been recommended by leading professionals across Ontario. This document contains the most effective and environmentally-safe control practices known at the date of publication. Information provided within this document was curated, based on the most recent research, experience, and literature available at this time. It complies with current provincial and federal legislation regarding aquatic invasive plant removal, control activities, pesticide usage, habitat disturbance, and species at risk protection. It is subject to change as legislation is updated or new research findings emerge. The information provided in this BMP is not to be considered legal advice. Interested parties are advised to refer to the applicable legislation relating to aquatic plant removal and control activities to address specific circumstances.

Check the website of the **Ontario Invasive Plant Council (OIPC)** (www.ontarioinvasiveplants.ca) and the appropriate government agencies for updates.

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Thank you to Kellie Sherman and Hayley Anderson for their contributions to the original document.

Last Updated: March 2025

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Ontario Ministry of Natural Resources

Inquiries regarding this document can be directed to the Ontario Invasive Plant Council (OIPC)

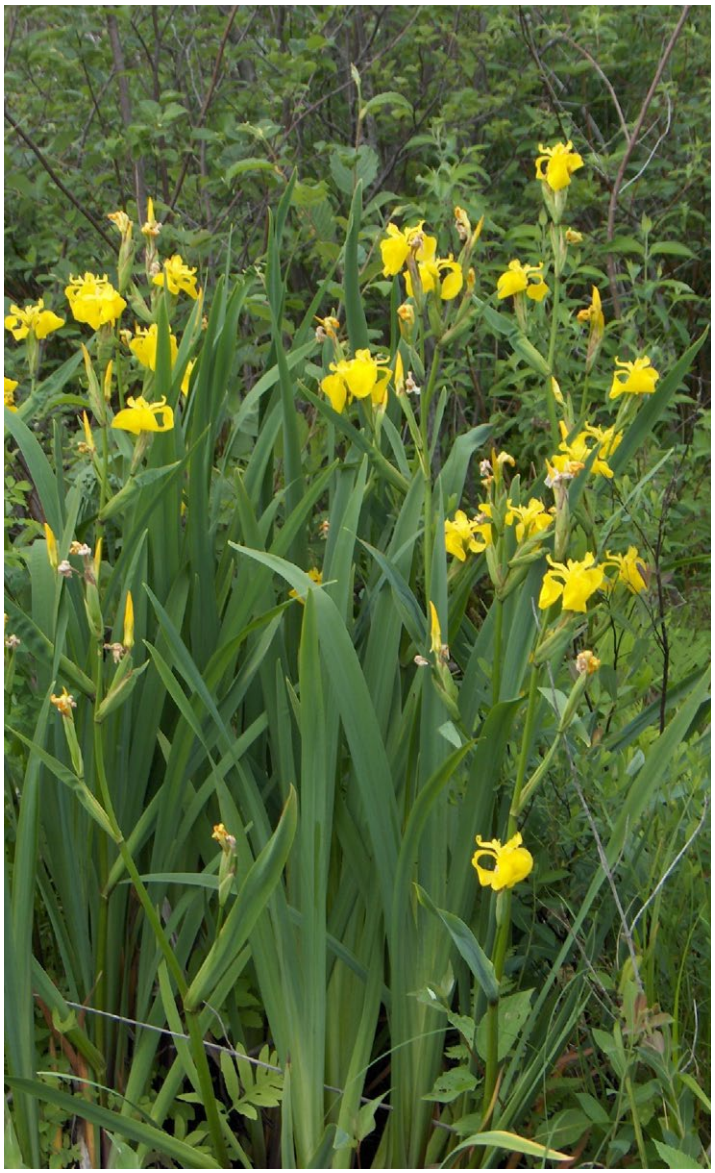
Email: info@ontarioinvasiveplants.ca

For more information on invasive plants in Ontario, please visit the following websites:

www.ontario.ca/invasivespecies, www.ontarioinvasiveplants.ca, www.invadingspecies.com or www.invasivespeciescentre.ca

Front and back cover photo courtesy of Wasyl Bakowsky.

Table of Contents



Yellow iris is an aquatic invasive plant commonly found along river and lake edges.

Photo courtesy of Dawn Sucee.

Native aquatic and wetland plants play an important role in our lakes and rivers, while aquatic invasive plants can negatively impact our environment and economy.

Photo courtesy of Wikimedia Commons.

Introduction

Aquatic and wetland plants ensure healthy aquatic environments and are important to our lakes, rivers, and wetlands. They provide many benefits to humans and animals including:

- **Water purification:** Act as biological filters to remove pollutants and excess nutrients from water.
- **Oxygenation:** Produce oxygen and absorb carbon dioxide released by fish.
- **Water clarity:** Provide calm areas for bottom sediment to settle, which is important for many fish species to be able to spawn.
- **Erosion control:** Root systems stabilize the soil and prevent erosion.
- **Shelter and camouflage:** Fish and small invertebrates can escape from predators.
- **Shade:** Help to cool the water, which benefits cold water fish.
- **Food and medicine:** Wild rice cultivation is important to the practices of First Nations communities.

However, when aquatic and wetland plants become invasive, they can threaten Ontario's waterways in a multitude of ways. Aquatic and wetland invasive plants are non-native species introduced to Ontario from outside their normal range by human activities and threaten the environment, economy, or society. These species can often grow fast and form dense mats, which alter light and nutrient availability, out-compete native plants, lower biodiversity and threaten species at risk. Dense mats create stagnant waters, which can support mosquito populations and contribute to algal blooms. During die-back, dense mats reduce dissolved oxygen, which can be lethal to fish and other aquatic organisms. Aquatic and wetland invasive plants can also inhibit recreational uses of waterways (such as boating, swimming or angling), disrupt storm drainage or hydro-electrical generation, increase flood probability, and impact water quality.

In recognition of the damage these aquatic and wetland invasive plants can cause, in 2013, Ontario developed an Aquatic Invasive Plant List of priority species of concern to enable work to safely remove them from provincial crown land and shorelands. This BMP document provides information on those original nineteen species, in addition to aquatic invasive plant species or genera that have subsequently been regulated under the Ontario *Invasive Species Act* (ISA, 2015) which came into force in 2016. Note that starry stonewort (*Nitellopsis obtusa*), a macroalgae, is not included within the scope of this BMP.

This document will present **species profile overviews** for each of the listed species, with the goal of assisting users in learning how to accurately identify and report sightings, understand more about the species biology and its impacts, and best practices for how to undertake safe and effective control.

Invasive aquatic plants that are included in this document, indicating their regulatory status under the *Invasive Species Act (2015)* at the time of publication of (March 2025):

Prohibited	Restricted	Not Regulated
• **Brazilian Waterweed** *(Egeria densa)* • **European Water Chestnut** *(Trapa natans)* • **Hydrilla** *(Hydrilla verticillata)* • **Oxygen Weed*** *(Lagarosiphon major)* • **Parrotfeather** *(Myriophyllum aquaticum)* • **Watermosses – *Salvinia* species** *(Salvinia molesta, S. auriculata, S. minima, S. natans)* • **Water Soldier** *(Stratiotes aloides)*	• **European Frog-bit** *(Hydrocharis morsus-ranae)* • **Eurasian Water-milfoil** *(Myriophyllum spicatum)* • **Fanwort** *(Cabomba caroliniana)* • **Floating Primrose-willow*** *(Ludwigia peploides)* • **Flowering Rush** (*Butomus umbellatus)* • **Phragmites** *(Phragmites australis* subsp. *australis)* • **Water Ferns – *Azolla* species*** *(Azolla filiculoides, A.cristata, A. pinnata)** • **Yellow Floating Heart*** *(Nymphoides peltata)*	• **Curly-leaved Pondweed** *(Potamogeton crispus)* • **Eurasian and Northern Milfoil hybrid** *(Myriophyllum spicatum × M. sibiricum)* • **European Lake Sedge** *(Carex acutiformis)* • **Purple Loosestrife** (*Lythrum salicaria)* • **Rough Mannagrass** *(Glyceria maxima)* • **Water Hyacinth** *(Eichhornia crassipes)* • **Water Lettuce** *(Pistia stratiotes)* • **Yellow Iris** (*Iris pseudacorus)*

**Species is regulated under the Invasive Species Act (ISA) at the time of publication of this document, but is not listed in Ontario's Invasive Aquatic Plant List, published in 2013 to define the rules for removing invasive aquatic plants described in O. Reg, 239/13 under the Public Lands Act.*

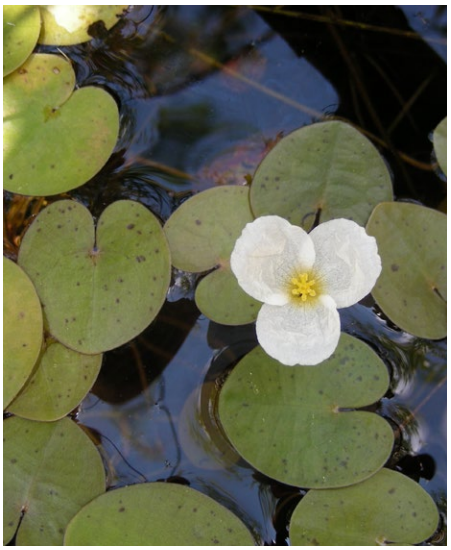
Invasive Plant Identification

Aquatic and Wetland Plant Types

There are **three types** of aquatic or wetland plant: submerged, floating, and emergent. Submerged aquatic plants grow almost entirely under the water. Floating aquatic plants can be free-floating (the leaves and/or stem float on the surface, with the roots hanging in the water and not attached to substrate), or they can be rooted in the substrate at the bottom of the lake. Emergent plants grow in shallow water, with roots penetrating the substrate, and most of their stems, leaves, and flowers growing out of the water. Some species can be a mix of these aquatic types, for example flowering rush and water soldier both have emergent and submergent forms. While the term aquatic or wetland plant is often used interchangeably in the literature, in this document wetland plant will refer to an emergent plant (found in shallow water) and/or a species that can also be found in wet or moist soils on terrestrial land.

Some species in the table below are listed in two columns as they can be more than one plant type.

Floating	Submergent	Emergent (wetland)
• **European frog-bit**	• **Brazilian Waterweed**	• **European Lake Sedge**
• **Water Hyacinth**	• **Hydrilla**	• **Rough Mannagrass**
• **Water Lettuce**	• **Parrotfeather**	• **Flowering Rush**
• **Watermosses**	• **Eurasian Water-Milfoil**	• **Yellow Iris**
• **European Water Chesnut**	• **Fanwort**	• **Invasive Phragmites**
• **Water Ferns**	• **Flowering Rush**	• **Purple Loosestrife**
• **Yellow Floating Heart**	• **Water Soldier**	• **Water Soldier**
• **Floating Primrose-willow**	• **Curly-leaved Pondweed**	• **Floating Primrose-willow**



Floating aquatic plant.

Photo courtesy of Robert Canning, Severn Sound Environmental Association.

Submergent aquatic plant.

Photo courtesy of Eric Snyder, Ministry of the Environment, Conservation and Parks.

Emergent aquatic or wetland plant.

Photo courtesy of Alex Yakovlev, www.inaturalist.org/observations/37955352, Licensed under CC-by-NC 4.0.

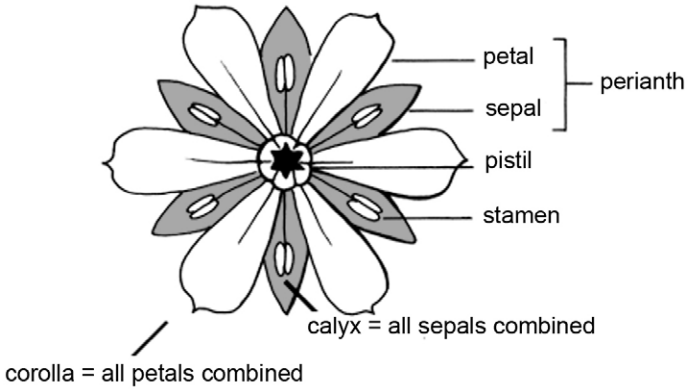
Learning how to identify an invasive plant species:

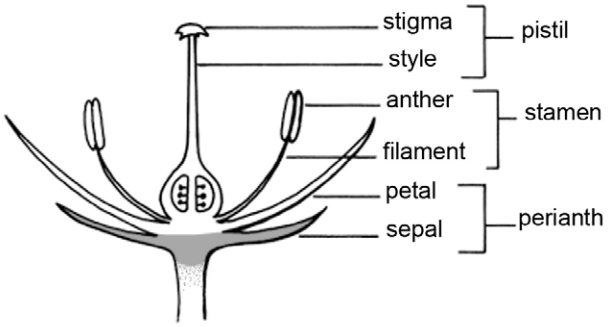
Proper identification of aquatic and wetland invasive plant species is critical to effective management. Be sure to confirm your sighting if unsure and learn how to differentiate the species from common lookalikes (native or non-native). Removing a native aquatic plant that is not intended for control may have negative impacts on the aquatic ecosystem. If you are unable to identify a plant, there are many agencies and organizations that can help. These include your local MNR office or Conservation Authority, a local horticultural or garden club, and other non-profit organizations such as the OIPC. You can also obtain assistance with invasive plant identification from the provincial **Invading Species Hotline at 1-800-563-7711**, www.eddmaps.org, or iNaturalist.org. There are several excellent field guides to identification to consider as well, such as the Wetland Plants of Ontario by Alan Harris, Linda Kershaw, and Steven Newmaster.

Botanical Terminology – a Brief Overview:

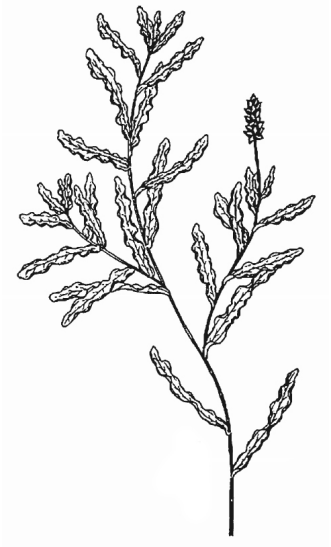
Plant Parts

Flower Parts:

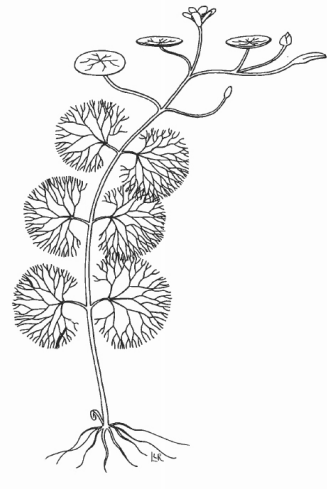




Leaf Arrangement:



Alternate

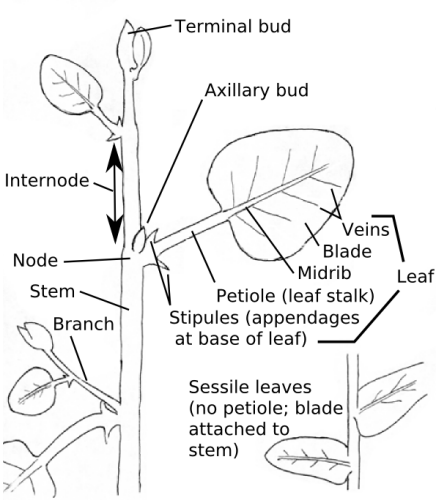


Opposite

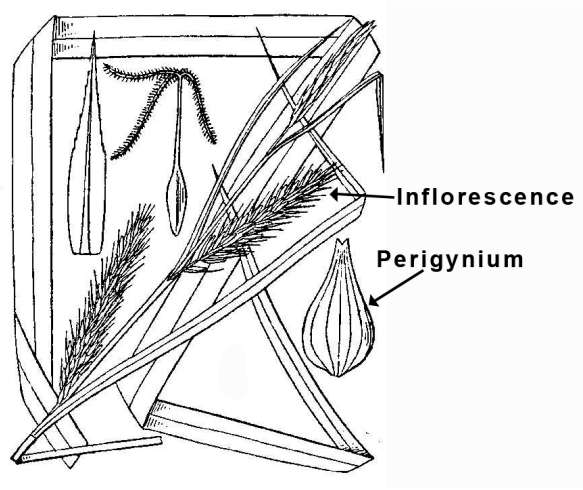
Whorled

Rosette

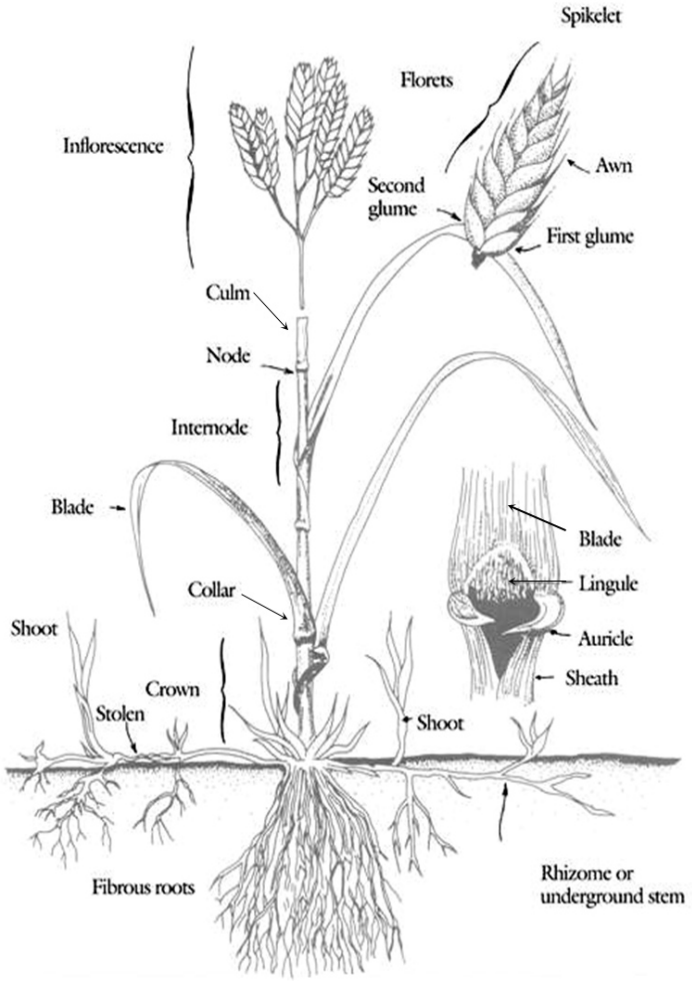
Parts of a Grass Plant



Parts of a Sedge Plant:



Stem Structures



Illustrations courtesy of:

Flower structures & leaf arrangement: University of Florida/IFAS Center for Aquatic and Invasive Plants.

Grass plant: National Drought Mitigation Center, Lincoln, Nb.

Stem structure: Mark Schonbeck, Virginia Association for Biological Farming

Prevent the Spread

Everyone can help prevent the spread of aquatic invasive plants by following these tips:

- **Report it:** If you think you see an aquatic or wetland invasive plant in the wild, particularly in a new location, take a picture, record the location and contact either the toll-free **Invading Species Hotline at 1-800-563-7711**, visit EDDMapS www.eddmaps.org, or search for the 'Invasive Species in Ontario' project on iNaturalist www.inaturalist.org to report a sighting.
- **Watch for it:** Learn what aquatic or wetland invasive plants look like and then monitor rivers, lakes, streams and other water bodies. Early detection of aquatic and wetland invasive plants can make it easier and cheaper to remove or control them.
- **Use native species:** Do not plant known invasive aquatic or wetland plants and if something starts acting invasive, consider removing it. Plant native species in your garden and ponds. Do not transplant aquatic or wetland invasive plants. Encourage your local garden centre to sell non-invasive or native plants. The Grow Me Instead guide includes alternative aquatic or wetland plants for some common aquatic invasive plants: https://www.ontarioinvasiveplants.ca/resources/grow-me-instead/
- **Don't let it loose:** Never release or deposit unwanted aquarium or water garden plants into natural waterways. Under the federal *Aquatic Invasive Species Regulations*, it is illegal to introduce any plant or animal into a body of water where it is not native.
- **Stop the Spread:** Inspect your boat, motor, trailer, and boating equipment such as anchors and fishing gear, centerboards, rollers, and axles. Remove any plants that are visible before leaving the waterbody. Wash or dry your boat, tackle, downriggers, trailer, and other boating equipment in order to kill harmful species not visible at the boat launch. Some species can survive more than two weeks out of water. Ensure that any aquatic or wetland invasive plants or plant parts that are removed during control activities are disposed of on dry land at a distance of at least 30 m from any body of water and in a manner that ensures that no part of the plant will re-enter the body of water or enter into any other body of water. If plant material is being transported to a disposal site it should be ensured that all plants or plant parts are secured and transported in a manner that ensures that the plants do not fall out of a vehicle during transport.

As of January 1st, 2022, Ontario has regulated watercraft (boats, canoes, kayaks, and watercraft equipment) as carriers of invasive species under the *Invasive Species Act* (ISA).

Before reaching a launch site or placing a watercraft in any body of water in Ontario, boaters are required to ensure their boat, boating equipment, vehicles or trailers are free of all:

- aquatic plants
- animals
- algae

It is illegal to place a boat, boating equipment or any vehicle or trailer into any body of water if there are any aquatic plants, animals or algae attached to it.

These rules recognize that it may not be possible to fully remove all aquatic plants, animals or algae (for example, hidden zebra mussels or small plant fragments in hard to reach locations) when removing the watercraft from the water at the launch site. Boaters can do a more thorough cleaning of their boat, utilizing special equipment, such as pressure washers at a more suitable location, to ensure their boat is completely free of aquatic plants, animals and algae.

- For example, it is recommended to rinse your boat and any equipment that normally gets wet with hot tap water (preferably greater than 60 °C), spray your boat and trailer with high-pressure water or dry your boat and equipment in the sun for at least 5 days before transporting them to another waterbody.
- Remove or open drain plugs to allow water to drain from the boat or boat equipment.

For more information about cleaning methods for boats and boat equipment please refer to the Ministry of Natural Resources Best Management Practices for Preventing the Spread of Aquatic Invasive Species – Guidance for Watercraft Users.

Early Detection and Rapid Response (EDRR)

Although invasive species prevention is key to avoiding the long-term impacts of invasions, it is not always possible to stop every invasive species. Early Detection and Rapid Response (EDRR) is a coordinated set of actions to find and eradicate new and emerging invasive species in a specific location before they become established. Once an invasive species is detected, a rapid response action plan is taken to prevent further spread, such as increasing public awareness and education, reducing pathways of spread, and eradication. When action is taken early it can significantly reduce the cost of control and increase chances of success for complete eradication.

Applicable Legislation and Permitting Requirements

(Last updated – March 2025)

Note: *This section provides a general overview of legal requirements which may apply to aquatic invasive plants and their control, it is not to be taken as legal advice. It is your responsibility to ensure that you operate in accordance with all legal requirements. You may need to refer to provincial legislation which can be found on the e-laws website:* http://www.e-laws.gov.on.ca/index.html.

Depending on the location, timing of work, and the type of management activities (e.g., mechanical/manual or chemical), permits, approvals or authorizations may be required from municipal, provincial or federal agencies before invasive species control can be initiated. Individuals undertaking control activities are responsible for ensuring that these are obtained and complying with any applicable legislation.

Additionally, if protected species or habitats are present, an assessment of the potential effects of the control project and authorization could be required. Depending on the species and its location, applications should be directed to the appropriate authorities.

While not an exhaustive list of permits or rules that may apply to aquatic invasive plant management, the following examples are provided for consideration.

European frog-bit removal.

Photo courtesy of Diana Shermet.

Table 1. Legislation pertaining to aquatic invasive plant management.

Legislation & Regulating Body	Purpose	Application to Aquatic Invasive Plant Management
Provincial		
***Invasive Species Act* (2015), Ontario Regulation 354/16** Ministry of Natural Resources (MNR) Applicable to Terrestrial and Aquatic Environments	Prevent the introduction and spread of invasive species	Of the 23 invasive aquatic plant species or genera included in this document, 7 are prohibited, 9 are restricted, and 7 are currently unregulated under the *Invasive Species Act* (ISA, 2015). It is illegal to import, deposit, release, breed/grow, buy, sell, lease or trade those aquatic invasive plant species or genera currently designated as **restricted** species in Ontario. It is also illegal to bring a restricted species into a provincial park or conservation reserve and to possess, transport, deposit or release them in these protected areas. There are exceptions under the regulation for the deposit or release of a **restricted** invasive species for the purpose of control if reasonable precautions are taken to prevent its spread outside the immediate area where control is occurring. It is illegal to import, possess, deposit, release, transport, breed, buy, sell, lease or trade **prohibited** invasive species in Ontario. **Exception*: the incidental movement in water of European water chestnut and water soldier as a result of the operation of a boat, in waters where these species are already present, is not restricted, provided reasonable precautions are taken while operating a boat to avoid transporting these plants to new areas of the waterbody. However, movement of European water chestnut and water soldier over land is prohibited. For more information, visit: https://www.ontario.ca/page/managing-invasive-species-ontario The Ministry of Natural Resources has developed Prevention and Response Plans for European water chestnut and water soldier to enable people and organizations to undertake low risk activities to monitor, control, and in some cases eradicate, these invasive plants without the need for an authorization under the ISA (2015). The plans also include detailed best management practices for these invasive plants. For more information on these plans, visit: https://ero.ontario.ca/notice/019-1163

Legislation & Regulating Body	Purpose	Application to Aquatic Invasive Plant Management
***Invasive Species Act* (2015), O. Reg 354/16** Regulation of watercraft and watercraft equipment as carriers of invasive species. Ministry of Natural Resources (MNR) Applicable to Terrestrial and Aquatic Environments	Prevent the introduction and spread of invasive species caused by the movement of watercraft between waterbodies	In Ontario, all boaters are mandated to remove aquatic organisms (e.g., aquatic plants) and drain water from watercraft and watercraft equipment prior to travelling overland or launching into any waterbody in Ontario. It is illegal to place a boat, boating equipment or any vehicle or trailer into any body of water if there are any aquatic plants, animals or algae attached to it. Those using watercraft to remove or monitor aquatic invasive plants should be familiar with these rules. For more information: https://www.ontario.ca/page/invasive-species-action-plans#boaters
***Public Lands Act*, O. Reg 239/13 (section 9)** Ministry of Natural Resources (MNR) Applicable to Aquatic Environments	Rules for removing invasive aquatic plants by mechanical devices or by hand	The *Public Lands Act* (PLA) applies to the removal of invasive aquatic vegetation from provincial Crown land and shore lands. In Ontario, the beds of most waterbodies are provincial Crown land. The PLA does not apply to federal lands and water bodies (e.g., the Trent-Severn and Rideau Canal waterways), or provincial parks and conservation reserves. If the species is listed in Ontario's Invasive Aquatic Plant List then the removal of these species by hand or mechanical devices (e.g., rake or cutter bar) from provincial Crown lands and shore lands does not require a work permit if you can follow and meet all of the rules outlined in O. Reg. 239/13 under the PLA. If you cannot meet all the prescribed rules, for example, if you want to conduct control or removal activities outside of the In-water Work Timing Window Guidelines, you will need a work permit. Before proceeding with your project, be sure to review and understand the rules to confirm you do not require a work permit: https://www.ontario.ca/page/remove-invasive-aquatic-plants

Legislation & Regulating Body	Purpose	Application to Aquatic Invasive Plant Management
Endangered Species Act Ministry of Environment Conservation and Parks (MECP) Applicable to Terrestrial and Aquatic Environments	Protection of endangered and threatened species and their habitat	The *Endangered Species Act* (ESA) prohibits the killing, harming, and harassing of species at risk (SAR) classified as extirpated, endangered or threatened, as well as damage and destruction of the habitat of endangered and threatened SAR. Activities that may adversely impact protected SAR or habitat may proceed in accordance with an ESA authorization (permit or agreement) or regulatory exemption. For the full list of SAR in Ontario and for information on permit requirements consult: http://ontario.ca/page/how-get-endangered-species-act-permit-or-authorization.
***Pesticides Act*, O. Reg 63/09** Ministry of Environment Conservation and Parks (MECP) Applicable to Terrestrial and Aquatic Environments	Regulation of pesticide use in Ontario	The *Pesticides Act* and Ontario Regulation 63/09 govern the sale, use, transportation, storage and disposal of pesticides in Ontario including license and permit requirements. Most invasive species control projects will require a licensed exterminator. Only pesticides registered under the federal *Pest Control Products Act* by the Pest Management Regulatory Agency (PMRA) can be used in Ontario. **The pesticide label is a legal document that must be followed exactly.** The use of pesticides in water almost always requires a permit from the MECP. The appropriately licensed exterminator in charge, along with the local MECP regional office can provide guidance on how to apply for a permit for aquatic vegetation control. For more information: https://www.ontario.ca/page/pesticides

Legislation & Regulating Body	Purpose	Application to Aquatic Invasive Plant Management
Federal		
Fisheries Act* and *Species at Risk Act Fisheries and Oceans Canada Applicable to Aquatic Environments	*Fisheries Act:* Protection of fish and fish habitat *Species At Risk Act:* Protection of aquatic species at risk	The *Fisheries Act* (and in some cases the *Species at Risk Act* [SARA]) applies when a proposed work, undertaking or activity in fish-bearing water results or is likely to result in: • The death of fish (by means other than fishing); • The harmful alteration, disruption or destruction of fish habitat; • The deposition of a deleterious substance (e.g., herbicides) in water frequented by fish; • Impacts to species listed as aquatic species at risk under the SARA or any part of their critical habitat. If there is risk of harm to fish or their habitat, authorization from DFO is required prior to undertaking any projects to avoid and mitigate impacts. The use of herbicides may be authorized to prevent the introduction or spread of, or to control aquatic invasive plants that may cause harm to fish, fish habitat or deathuse of fish. To remain in compliance with the *Fisheries Act* and the SARA consult the guidance found at the following websites: **Projects near water** - www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html
***Transport Act*, Historic Canals Regulations** Parks Canada Agency Applicable to Aquatic Environments	Management, proper use and protection of historic canals	Authorization is required from the Parks Canada Agency for any plant removal activity in federal waters under their jurisdiction including national parks and historic sites. For the Trent-Severn Waterway and the Rideau Canal, permit applications and guidelines for aquatic plant removal can be obtained on-line: https://parks.canada.ca/lhn-nhs/on/trentsevern/info/services-immobiliers-realty/permis-permits

Legislation & Regulating Body	Purpose	Application to Aquatic Invasive Plant Management
***Migratory Birds Convention Act* (MBCA) & Regulations** Environment and Climate Change Canada (ECCC) – Canadian Wildlife Service (CWS) Applicable to Terrestrial and Aquatic Environments	Protection of migratory birds, and their nests and eggs	When undertaking your project, you should take precautions to avoid harming migratory birds, nests and eggs. This includes: • Understanding how migratory birds and their nests are legally protected; • Planning your activity ahead of time, evaluate if the activity may cause harm to migratory birds, and determine what measures can be taken to avoid causing this harm; • Develop and implement preventative and mitigation measures, such as beneficial management practices. For more information please visit: https://www.canada.ca/en/environment-climate-change/services/migratory-birds-legal-protection/convention-act-regulations.html
***Pest Control Products Act* (PCPA)** Pest Management Regulatory Agency (PMRA), Health Canada Applicable to Terrestrial and Aquatic Environments	Regulation of pest control products in Canada	The pesticide label is a legal document. Pesticides must be applied in accordance with all label directions. Using a pesticide to treat a species not listed on the label violates the *Pest Control Products Act* and may incur penalties. Ensure you have the most current label and are aware of any re-evaluation decisions. Visit the Pest Management Regulatory Agency's product label search site at https://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php

Invasive Plant Management Planning

Once an invasive species is established in an area, it is important to use a control plan that incorporates integrated pest management (IPM) principles. IPM is a decision-making process that helps control pest species effectively, economically and in an environmentally sound manner. IPM principles sustain healthy landscape, waterways or waterbodies while protecting human health. Knowledge of the pest species (i.e., biology of the plant and timing of the life cycle) and its surrounding environment along with a variety of control methods are used to prevent and control infestations.

Once an aquatic or wetland invasive plant has been confirmed at a location, a control plan should be developed based on infestation size, site accessibility, potential for spread and the risk of environmental, economic or social impacts. Site specific conditions must also be considered such as native plant diversity, wildlife and water table fluctuations. A detailed inventory of each site is strongly recommended before starting control efforts. This will help minimize negative impacts and maximize effective control.

A more broadly scoped management strategy is needed if an aquatic or wetland invasive plant has become widely established. A strategic, landscape-level approach to management should be undertaken that aids in bringing together partners, landowners, and land managers. This approach is designed to work towards common goals that consider the site-level and broader landscape needs. It makes it easier to use resources efficiently, coordinate management activities and accomplish strategic goals. Effective management of aquatic or wetland invasive plants often requires repeated treatments, ongoing monitoring, and a combination of control methods (i.e., hand pulling or digging and herbicide use).

Defining land use objectives and the desired plant community is key, since total infestation removal isn't always practical, especially for large areas. From here, develop an appropriate IPM strategy which takes into consideration the biology and life cycle of the plant in addition to using a combination of management techniques.

Water soldier threaten's Ontario's waterways.

Photo courtesy of Michael Oldham, iNaturalist, www.inaturalist.org/observations/239182487, licensed under CC-by-NC.

After an infestation is confirmed, initial control efforts should be focused on preventing spread. When action is taken early it can significantly reduce the cost of control and long-term efforts required. With large infestations and limited time and resources, control work can seem daunting. It is important to develop a feasible, long-term strategy with the following considerations:

1. **Protect** federally, provincially, and regionally rare species and communities by removing aquatic and wetland invasive plants and ensuring rare species are not negatively impacted by control efforts. Landowners are responsible for ensuring that their project follows provincial, federal, and municipal laws, including the provincial *Endangered Species Act*, 2007 (ESA) and federal *Species at Risk Act*. For species-specific information consult: https://www.ontario.ca/page/species-risk-ontario.
2. **Ensure** all landowners, including adjacent landowners, and other users of the waterbody/waterway have been identified and consulted before control takes place. It is also important to consult with local Indigenous communities.
3. **Contain:** If there are limited resources available, remove the outlying populations first (isolated plants or satellite populations), to prevent further spread. Protect areas where aquatic and wetland invasive plants are absent or just appearing. When action is taken early it can significantly reduce the cost of control. The native habitats in these areas are probably most intact and will recover from the infestation most quickly. Also consider relevant environmental and ecological processes that may be affecting spread such as wind direction, flow direction and animal spreading of seeds (zoochory) as well as how the reproductive strategies of the plant interact with those processes. During control, use temporary floating barriers, seine nets etc. to assist with preventing dispersal downstream.
4. **Work inward:** If more resources are available, work from the outlying or satellite populations inward into larger, "core" populations to prevent spread into new areas. In many cases, resource limitations may prohibit the immediate removal of entire core populations. Under these circumstances, core areas should be prioritized and addressed strategically.
5. **Consider sensitive ecological areas:** Concentrate on preventive strategies in high-priority ecological areas or areas where the aquatic or wetland invasive plant is going to cause the most problems in terms of spread, such as the most productive or sensitive part of an ecosystem, along a creek, near species at risk, or a sensitive aquatic habitat such as a wetland. Pay special attention to disturbed sites which can be quickly colonized by invasive plants. Reduce the spread of aquatic invasive plants by following the Clean Equipment Protocol and Clean, Drain Dry Best Practices.
6. **Logistics and costs:** Review the different control options and costs, with consideration to the connectedness of the aquatic features, the surrounding habitat, time of year, and type of land (i.e., wildlife preserve, public access, canal/shipping, etc.).
7. **Consider** dedicating a certain time each year to control efforts and make it a joint effort with neighbouring landowners and/or land managers. Ensure that you follow the in-water work timing windows and the more effective times for control based on the biology of the aquatic invasive plant.
8. **Follow-up monitoring** is crucial to remove new plants or address resprouts that may emerge after initial control efforts. Control is most successful using a combination of techniques applied more than once per season, as well as repeat monitoring and control over multiple years.

Species Profiles

This section will review the following topics for each species (arranged in alphabetical order): Introduction, identification, look-alikes, biology and life cycle, habitat, distribution, pathways of spread, impacts, and control.

- Brazilian Waterweed (*Egeria densa*)
- Curly-leaved Pondweed (*Potamogeton crispus*)
- European Frog-bit (*Hydrocharis morsus-ranae*)
- European Lake Sedge (*Carex acutiformis*)
- European Water Chestnut (*Trapa natans*)
- Eurasian Water-milfoil (*Myriophyllum spicatum*)
- Eurasian and Northern Milfoil hybrid (*Myriophyllum spicatum* × *M. sibiricum*)
- Fanwort (*Cabomba caroliniana*)
- Floating Primrose-willow (*Ludwigia peploides*)*
- Flowering Rush (*Butomus umbellatus*)
- Hydrilla (*Hydrilla verticillata*)
- Oxygen Weed (*Lagarosiphon major*)*
- Parrotfeather (*Myriophyllum aquaticum*)
- Phragmites (*Phragmites australis* subsp. *australis*)
- Purple Loosestrife (*Lythrum salicaria*)
- Rough Mannagrass (*Glyceria maxima*)
- Water Ferns – *Azolla* species (*Azolla filiculoides, A. cristata, A. pinnata*)
- Water Hyacinth (*Eichhornia crassipes*)
- Water Lettuce (*Pistia stratiotes*)
- Watermosses – *Salvinia* species (*Salvinia molesta, S. auriculata, S. minima, S. natans*)
- Water Soldier (*Stratiotes aloides*)
- Yellow Floating Heart (*Nymphoides peltata*)*
- Yellow Iris (*Iris pseudacorus*)

Red = Prohibited
Blue = Restricted
No color = Not regulated
(*) - Species is regulated under the *Invasive Species Act* (ISA) but is not listed on the Ontario Invasive Aquatic Plant List.

Brazilian waterweed forms large, dense monocultures.
Photo courtesy of William T.Haller, University of Florida, Bugwood.org.

Brazilian Waterweed
(Egeria densa)

Regulatory Status under Ontario's ISA: Prohibited Species.

It is illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade this prohibited invasive species in Ontario.

Introduction

Type of aquatic plant: Submerged, aquatic plant.

Other names: Brazilian elodea, Brazilian waterweed, common waterweed, dense waterweed, *Egeria*, leafy elodea, South American waterweed, and *Anacharis* (most often in the aquarium trade). It is a member of the Hydrocharitaceae (Frog-bit) family.

Area of origin, introduction date and location: Native to South America. It was introduced to North America in the late 19th century and was first recorded in Canada from Vancouver Island in 1974. It is not yet documented in Ontario, but has established populations in the Great Lakes basin, including Illinois, Indiana, New York and Pennsylvania.

Identification

Size and Stem:

Sparsely branched, up to 10 - 90 cm long. Stems break easily and form new plants. It has areas along the stem called "double nodes", which produce roots and branches that help establish a new plant from a plant fragment.

Leaves:

Heterophyllous (forms that occur above water (floating) and below water (submerged)). The submerged leaves are opposite or in whorls of 3 and are smaller in size than the middle and upper leaves which are in whorls of 4 - 6 and are between 12 - 40 mm long. The floating leaves are bright green and found in regular increments which become denser towards the tip of the stem. They are attached directly to the stem, without a petiole. The leaf margins also have fine serrations which can only be seen under magnification.

Flowers:

Dioecious (single plants bear only male or female flowers). In the United States, only male plants have been observed, which do not produce seed. The female plants have not been found outside of South America. Male flowers occur in groups of 2 - 4, with three white petals with a yellow centre, measuring 10 - 15 mm long. They emerge just above or at the water surface on slender stalks projecting from leaf axils near the stem tip.

Fruits:

When produced, are berry-like, oval-shaped, 7 - 8 mm wide and 3 mm wide.

Roots:

Filament-like at the base of plants and occur at some nodes.

Brazilian waterweed is a submerged, aquatic plant that grows up 10 - 90 cm long.

Photo courtesy of Dina Nesterkova, iNaturalist, www.inaturalist.org/observations/68122783.

Floating leaves of Brazilian waterweed are bright green with fine serrations.

Photo courtesy of Dina Nesterkova, iNaturalist, www.inaturalist.org/observations/77587507.

The stems of Brazilian waterweed are sparsely branched and break easily.

Photo courtesy of Gail A. Baker, iNaturalist, www.inaturalist.org/observations/86591697.

Flowers are white with a yellow centre and occur just above or at the surface of the water.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/85514746.

Brazilian Waterweed and its Lookalikes

Brazilian waterweed resembles native waterweeds (*Elodea canadensis, E. nuttallii*), but the native waterweeds have shorter leaves and 3 leaves in a whorl, compared to 4 to 6 in a whorl on Brazilian waterweed. Brazilian waterweed is also very similar to the invasive aquatic plant Hydrilla (*Hydrilla verticillata*). However, it does not produce tubers to help it over-winter like Hydrilla, and does not have as obvious toothed leaf margins.

	Brazilian Waterweed *(Egeria densa)* INVASIVE	**Canada Waterweed** *(Elodea canadensis)* NATIVE	**Nuttall's Waterweed** *(Elodea nuttallii)* NATIVE
	 Photo courtesy of Robert Videki, Doronicum Kft, Bugwood.org.	 Photo courtesy of Christian Fischer.	 Photo courtesy of Christian Fischer.
Plant Type	• Submerged	• Submerged	• Submerged
Stems	• Erect, branched or unbranched • Up to 2 m long	• Slender, many branches formed along stem • Up to 2 m long	• Slender, many branches formed along stem • Up to 1 m long
Leaves	• **Lowest leaves opposite or in whorls of 3, smaller in size than middle and upper leaves** • **Middle and upper leaves in whorls of 4 - 6** • Small, 12 - 40 mm long • Bright green • **Leaf margins minutely toothed**	• Attached directly to the stem in whorls, with 3 leaves per whorl • **Leaves become densely crowded toward the top of plant** • Small, 5 - 13 mm long, 1 - 5 mm wide • Lance-shaped on male plants and oval on female plants • Bright green when young • **Leaf margins flat**	• Attached directly to the stem in whorls, with 3 leaves per whorl • Small, 4 - 15.5 mm long, less than 1.5 mm wide (narrow) • Lance shaped on male plants, oval on female plants, **sharply pointed at tip** • Pale green • **Leaf margins folded**
Flowers	• **Flowers do not occur in North America**	• **Male or female plants (dioecious) found in upper leaf axils. Rise to or above the water surface at maturity** • Female flowers raised to surface of water by 3 - 20 cm long, thread-like stalks	• Small, white with 3 petals at tips of long stalks • Rise to or above the water surface at maturity

Biology and Life Cycle

Brazilian waterweed is a perennial and in North America, reproduction is entirely by fragmentation as female plants are not known to occur outside its native range. When a stem part breaks off, new plants are formed from the double nodes. Research has shown that plants grow when water temperatures reach 10 °C. Optimum growth occurs in the spring and fall and is generally only limited in extremely warm (above 30 °C) and extremely cold temperatures (below 4 °C). This plant does not have tubers, turions or rhizomes to overwinter. Rather, relies on stems and root fragments to quickly reinvade in the spring.

Habitat

Brazilian waterweed grows in shallow lakes, streams, ponds and ditches. It is more common in warm climates, but is capable of surviving winter. It tolerates a wide range of environmental conditions, including low light and low temperatures, and often grows in habitats similar to that of Eurasian water-milfoil. It typically occurs at depths of up to 7 m. It has low light requirements, tolerates a wide range of pH and can survive in turbid environments.

Distribution

Brazilian waterweed is not currently known in Ontario. It is found in British Columbia, and 42 States in the US, including six within the Great Lakes Basin (Minnesota, Illinois, Indiana, Ohio, Pennsylvania, New York). It is found on every continent except for Antarctica, and has been reported as invasive in Africa, Europe, Australia, and in South America.

For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Pathways of Spread

Brazilian waterweed is commonly sold as an aquarium plant (under the name Anacharis) and, while now illegal to import, possess, transport, deposit, release, propagate, buy, sell or trade, may still be available illegally in Ontario. It may enter the natural environment by intentional plantings in water gardens, improper disposal of aquarium contents into waterways, or be carried into waterways from flood and rain events. It may be further spread between waterbodies by plant fragments attached to boats, trailers and angling gear.

Impacts

Brazilian waterweed forms dense monoculture stands over very large areas, just below the water's surface. It acts as an ecosystem engineer as its dense mats can alter light and nutrient availability. It clogs irrigation systems, drainage canals, storm water ponds and hydroelectric dams. It also interferes with recreational water use, traps sediment and restricts water movement, reducing water clarity and flow. The large stands shade out native plant species, reducing plant biodiversity. They also reduce dissolved oxygen during die-back, which negatively impacts fish and other aquatic organisms. Stagnant waters created by these mats can support large mosquito populations. These mats can affect access to recreational activities such as fishing, swimming or boating. Dense mats can entangle in boat propellers and impede navigation.

Control Measures

Early detection and rapid response is key to prevent the establishment of Brazilian waterweed. Prevention is the most effective way to reduce the spread of this invasive plant on a long-term scale. Management options must be considered carefully to avoid spreading the plant which can reproduce vegetatively. Brazilian waterweed can be challenging to manage because most control efforts risk fragmenting the plant which can lead

to it regenerating. Refer to the Prevent the Spread section (**page 6**) for details on how you can prevent the spread of invasive aquatic plants.

This plant is not currently known to be established in Ontario. If you think you've seen Brazilian waterweed or another aquatic or wetland invasive plant in the wild, take a picture, record the location and contact either the toll-free **Invading Species Hotline at 1-800-563-7711**, visit EDDMapS www.eddmaps.org, or search for the 'Invasive Species in Ontario' project on iNaturalist www.inaturalist.org to report a sighting.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations.

Manual Control

Hand Removal or Mechanical Harvesting:

Hand pulling is feasible for smaller infestations. Mechanical harvesting can be used to remove the surface mats to create areas of open water, however, this process can produce thousands of fragments that can unintentionally expand populations.

Cultural Control

Benthic Barrier:

Benthic barriers are covers laid on the bottom sediment of a water body to block sunlight, preventing plants from photosynthesizing and suppressing their growth. The use of benthic barriers can be effective on small populations of Brazilian waterweed, as it becomes very labour intensive with larger populations. It is important to use heavy PVC pond liners (18 oz or PVC vinyl) that are gas permeable to prevent them from rising to the surface. The benthic barrier should extend across the entire infestation including along the margins (including channel banks). Barriers need to be secured to the sediment using bricks or rocks. This method can impact non-target species and should not be used in ecologically sensitive areas. Since Brazilian waterweed does not produce turions or tubers, the likelihood of reinfestation is reduced.

Regulatory restrictions must also be considered. Benthic barriers are not permitted by Parks Canada for use in the Trent-Severn Waterway or the Rideau Canal. For projects on Provincial Crown land or shore lands, placement of these materials requires a work permit from MNR under the *Public Lands Act* as this control method does not fall under the provincial rules for removing invasive aquatic vegetation in Ontario without a work permit.

Water-level Control:

In areas where the water levels can be manipulated (i.e, landlocked ponds, irrigation channels, stormwater ponds and reservoirs), water drawdowns can be an effective control method as Brazilian waterweed is susceptible to desiccation and freezing because seeds, tubers or turions are not produced for regrowth. However, fragments within mounds of substrate that maintain sufficient moisture, can be viable for up to 30 days. As such, winter drawdowns where dry and temperature freezing conditions are present, are more effective.

Biological Control

There are currently no biological control agents available to control Brazilian waterweed in Canada. However, a fly species is being tested for hosted specificity.

Chemical Control

Currently there are no herbicides registered to control Brazilian waterweed in Canada.

Curly-leaved pondweed forms thick mats of vegetation.

Photo courtesy of Michael Oldham, www.inaturalist.org/observations/121440997, licensed under CC-by-NC.

Curly-Leaved Pondweed
(Potamogeton crispus)

Regulatory Status under Ontario's ISA: Not Regulated.

Introduction

Type of aquatic plant: Submerged, aquatic plant.

Other names: Member of the Potamogetonaceae (Pondweed) family and is also known as curly pondweed.

Area of origin, introduction date and location: Native to Eurasia, Africa, and Australia. It was first detected in North America in 1841 in the city of Philadelphia and then spread rapidly through Great Lakes regions such as Massachusetts and New York. It was first detected in Canada in Ashbridges Bay, Ontario in 1891.

Identification

Plant Type:

Submerged.

Size and Stem:

Flattened, red-brown, branching stems, which grow to the water's surface, forming thick mats of vegetation. Can grow up to 1 m in length, or longer in deeper water. *Winter form:* flattened, limp, narrow, blue-green leaves, few stems and thin rhizomes. *Spring or summer form:* crisp texture, wavy leaf margins, wider, dark-green and/or red-brown.

Leaves:

Submersed, alternate, oblong, narrow, 2.5 - 7.5 cm long. The leaves have distinct margins that are wavy (resemble lasagna noodles), finely and sharply toothed, rounded at the apex. Prominent mid-vein, stalkless (leaves attached directly to stem). Semi-translucent, olive-green and may turn reddish as they get closer to the water's surface. Leaves become denser at the bottom of the stem. There are no floating leaves. Vegetative buds called turions develop at branch tips and leaf axils.

Flowers:

Emergent, extending above the water in small spikes. Spikes have 3 - 5 whorls of flowers, flowers are small (3 mm wide), white or brownish, each with a 4-parted style surrounded by 4 stamens, each stamen with a green to brown, ladle-shaped, sepal-like appendage. Flowers May to September.

Fruits:

Red-brown, single seeded, 6 x 2.5 mm, with a curved beak 2 - 3 mm long. Fruit is not often formed.

Roots:

Rooted in bottom sediment. Rhizomes are pale yellow or reddish, rooting at the nodes. Many plant stems can be connected to a single rhizome.

Submersed leaves are alternate with distinct wavy margins.

Photo courtesy of Peter Zika, iNaturalist, www.inaturalist.org/observations/216129860.

Leaves are finely and sharply toothed.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/156270078.

Flowers extend above the water in small spikes.

Photo courtesy of Susan Elliott, iNaturalist, www.inaturalist.org/observations/4071242.

Fruits are red-brown, single seeded, with a curved beak.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/121440997. Licensed under CC-BY-NC.

Curly-Leaved Pondweed and its Lookalikes

	Curly-Leaved Pondweed *(Potamogeton crispus)* INVASIVE	Richardson's Pondweed *(Potamogeton richardsonii)* NATIVE
	 Photo courtesy of Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.	 Photo courtesy of inaturalist. www.inaturalist.org/observations/131110396.
Plant Type	• Submerged	• Submerged
Leaves	• **Leaf margins wavy, finely and sharply toothed** • **Rounded or blunt at the tip** • **Stalkless (leaves attached directly to stem)** • **Stipules are not fibrous** • Linear-oblong leaves • No floating leaves • Prominent midvein flanked by 1 or 2 pair of lateral veins	• **Leaf margins wavy, toothless** • **Pointed tip** • **Clasp the stem** • **Stipules are fibrous (whitish membranous appendage not connected to the leaf blade, shreds into persistent fibers)** • Lance to egg-shaped leaves • No floating leaves • Prominent midvein flanked by 13 - 33 lateral veins, 3 - 5 of which are more prominent than the rest
Flowers/Fruit	***Flowers:*** • Cylindrical spike held above surface of the water • Spikes have 3 to 5 whorls of flowers, each flower with a 4-parted style surrounded by 4 stamens, each stamen with a green to brown, ladle-shaped, sepal-like appendage ***Fruits:*** • **Dry seed (achene) with knobby keel along back edge, long curved beak (2 - 3 mm long)** • **Presence of turions at branch tips and in leaf axils**	***Flowers:*** • Cylindrical spike held above surface of the water • Spikes have 6 to 12 whorls of flowers, each flower with a 4-parted style surrounded by 4 stamens, each stamen with a green, ladle-shaped, sepal-like appendage ***Fruits:*** • **Dry seed (achene) without keels along back edge, long erect beak (0.4 - 0.7 mm long)** • **Turions are not present**

Biology and Life Cycle

Curly-leaved pondweed can act as a perennial or winter annual, with a unique growth cycle compared to other submersed aquatic plants. Reproduction is almost exclusively vegetative through rhizomes and buds called turions. In the fall, turions break dormancy and begin to sprout new plants. The plants continue to grow through the winter, even under thick ice and snow cover, then grow rapidly in early spring when water temperatures are still cool (10 - 15 °C). In May or early June, plants flower, fruit, form turions, and then die-back. Turions are formed in the leaf axils and branch tips, and each turion can have 2 - 7 dormant buds. Once formed, turions sink to the bottom of the waterbody and lie dormant throughout the summer. Each plant can produce hundreds of turions, which have high germination rates, and can remain viable in the sediment for two or more years.

Habitat

Curly-leaved pondweed prefers alkaline, nutrient-rich, calcareous waters. Its presence is often an indicator of eutrophic conditions, or water bodies with high levels of nitrogen, phosphorous and organic matter. It can be found in disturbed, polluted, or very turbid waters. It can grow in summer and winter conditions. As a cold-tolerant species it will grow through winter, even under ice cover. It typically grows in water that is 1 to 3 m deep but has been found at depths up to 7 m. Its preferred habitat is still water, but it is tolerant of flow. It can be found in almost every type of aquatic environment including freshwater lakes, rivers, streams, marshes, ponds, ditches, and canals, and can root in silt, clay, gravel, or sand sediment.

Distribution

In Ontario, curly-leaved pondweed is currently confined to the southern portion of the province and the Georgian Bay-Severn River area. In Canada, it is found in southwestern Quebec, British Columbia, Alberta, Saskatchewan, New Brunswick, Ontario, Quebec and is also found throughout most of the United States.

For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Pathways of Spread

Curly-leaved pondweed can be spread by plant fragments, rhizomes, or turions that are accidentally transported on boats, trailers or other equipment (i.e., fishing or scuba gear). It is believed that curly-leaved pondweed may have been intentionally spread by humans in the early 1900s to create habitat for waterfowl and wildlife. It may have also spread accidentally as a contaminant in water used to transport fish and fish eggs to hatcheries or released into nearby waterbodies when aquarium contents are discarded into waterbodies. It can also spread over long distances by migratory waterfowl or expand locally in flowing water or flood events.

Impacts

Curly-leaved pondweed is a very effective canopy-forming plant. Its ability to grow through winter and early spring give it a competitive advantage, allowing it to form dense monocultures, outcompete native submersed vegetation and reduce biodiversity. These dense monocultures impede water flow, as well as recreational activities such as angling, boating and swimming, and reduce the aesthetic value of waterfront property and tourism. In mid-summer, thick mats of curly-leaved pondweed begin to die back. This decaying vegetation can affect oxygen levels in the water, negatively impacting fish and other aquatic species. A large amount of phosphorous is also released during decomposition, contributing to algal blooms.

Control Measures

Control for curly-leaved pondweed should take place in spring or early summer, before the flowering stalks appear above the water surface and/or before new turions are produced. Consider its unique life cycle, as the first pondweed to emerge in spring then die back in mid-summer. Before they die, plants form turions which lie dormant during the summer when native plants are growing. The target of control is to reduce the turion bank; removing plants after turions are produced is not effective at reducing curly-leaved pondweed. Turions can lie dormant for a few growing seasons, therefore control efforts should take place for a number of consecutive years.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (**page 6**) for details on how to report and prevent the spread of aquatic invasive plants.

Manual Control

Manual and mechanical control includes raking, hand pulling or cutting, mechanical harvesting, and benthic barriers. Raking and hand cutting remove the plants at the sediment surface while harvesting removes the top 1.5 m of the plant.

Hand Removal:

Hand pulling individual plants or small infestations can prevent the spread of the plant. When hand pulling, focus on removing the buried turions and rhizomes, as well as the plants fragments that may break off. Fragments that are left behind may contain turions and can grow new plants. To reduce the potential of resprouting or seed spread, ensure all plant fragments are removed from the water and away from the bank. This method can be time-consuming and labor-intensive.

Raking:

Raking removes curly-leaved pondweed at the sediment surface, and when conducted early in the season, can assist in preventing turion production. However, raking can cause plant fragments to break off, which can contribute to the spread of the plant. Raking should also be combined with hand pulling to remove buried turions and rhizomes, as well as plant fragments. In a recreational area in Montana, raking a large area or pondweed over a course of three years was effective at reducing infestations.

Mechanical Control

Cutting:

Cutting curly-leaved pondweed can be effective for small areas. Cutting removes curly-leaved pondweed at the sediment surface, and when conducted during the right time of the season, can assist in preventing turion production. Combine with hand pulling to remove buried turions and rhizomes, as well as plant fragments. A three-year, whole lake cutting approach in infested Minnesota lakes found early season cutting at the sediment surface to be effective in preventing turion production.

Mechanical Harvesting:

Mechanical harvesters can be effective in clearing large areas. Early season cutting can prevent turion production. However, it is important to remember that mechanical harvesting only cuts the plant and does not remove the seedbank and is less selective. It is also important to keep in mind the amount of plant material that is going to be removed and disposed of properly.

Benthic Barriers:

Benthic barriers can be effective in localized areas, such as around a dock or a swimming area. The barriers can help to prevent turions from growing new plants. A benthic barrier made of burlap will allow for native plants to grow, but will also decompose within two years. If the barrier is maintained, it can provide long-term control.

Biological Control

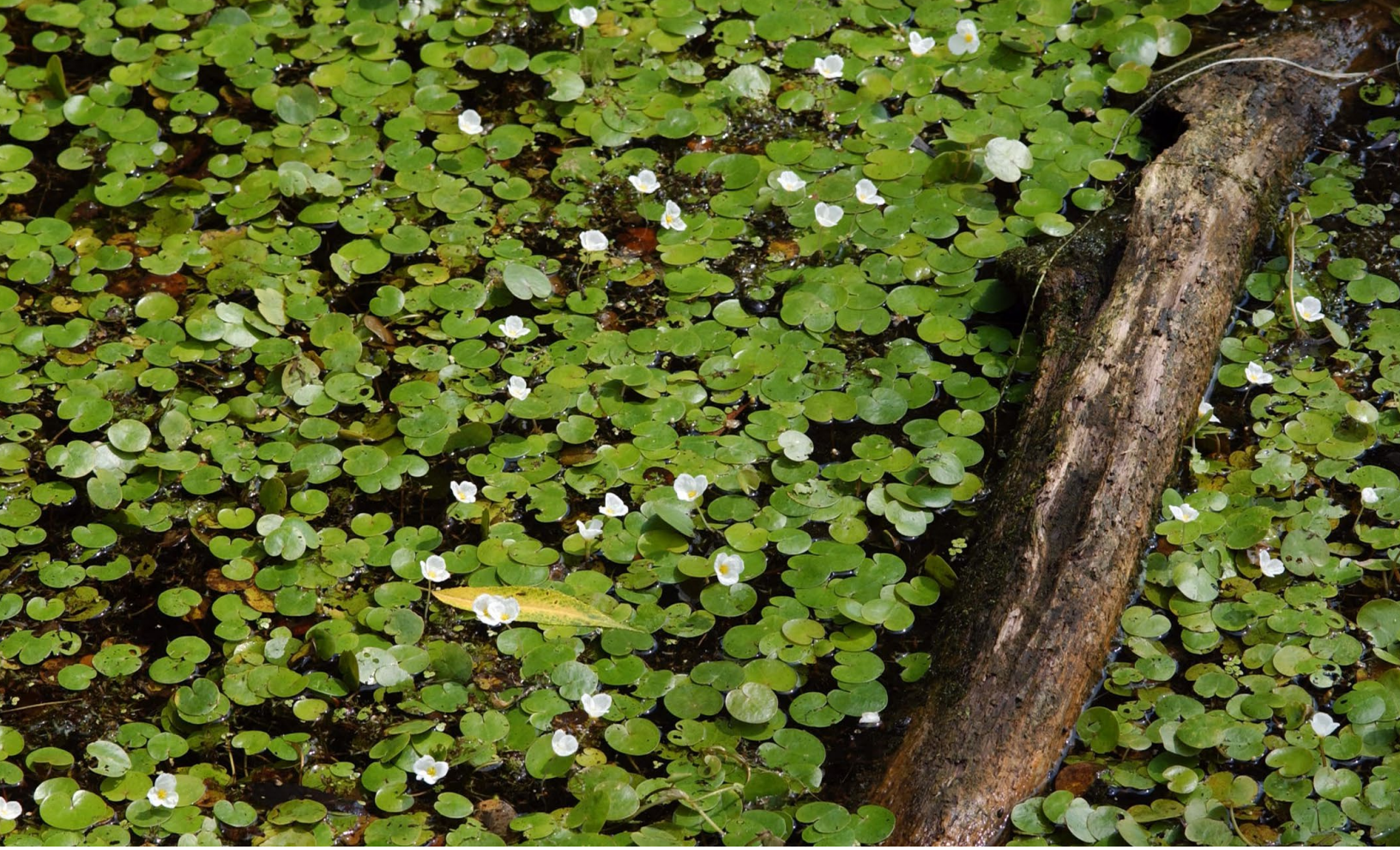
There are no biological controls available for curly-leaved pondweed in Canada.

Chemical Control

Contact herbicides with the active ingredient diquat have shown to reduce root biomass and suppress turion production. Herbicide application should take place in early spring in order to reduce the impact of the herbicide on native aquatic plants. There is also another herbicide registered for use on curly-leaved pondweed containing the active ingredient acrolein.

Leaves of curly-leaved pondweed are wavy.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/103472379. Licensed under CC-by-NC.



European frog-bit forms dense mats in slow-moving water.

Photo courtesy of Michigan Sea Grant.

European Frog-Bit
(Hydrocharis morsus-ranae)

Regulatory Status under Ontario's ISA: Restricted Species.

It is illegal to import, deposit, release, breed/grow, buy, sell, lease or trade this restricted invasive species in Ontario. It is also illegal to bring a restricted species into a provincial park or conservation reserve and to possess, transport, deposit or release them in these protected areas.

Introduction

Type of aquatic plant: Free-floating, aquatic plant.

Other names: Member of the Hydrocharitaceae (Frog-bit) family.

Area of origin, introduction date and location: Native to Eurasia, intentionally brought over from Switzerland for possible ornamental use at the Central Experimental Farm, Ottawa in 1932, and subsequently observed in the nearby Rideau Canal in 1939. Since then, it has gradually spread and can be found throughout southern Ontario and is now being seen in waterbodies along the southern margin of the Canadian Shield.

Identification

Size and Stem:

Free-floating, can root in shallow water. Turions 0.5 - 1 cm arise from stolon nodes.

Leaves:

Leathery, small, round to heart-shaped, 2.5 - 6 cm (about size of a Canadian one-dollar coin), forming a rosette. Upper side green, underside purple-red with spongy air pockets (aerenchyma) along middle vein of leaf. Able to float on the water's surface due to its spongy underside.

Flowers:

Single emergent white flower, three rounded petals, yellow centre. June to September.

Fruits:

Globose berry (15 - 20 seeds, up to 74).

Roots:

Unbranched, up to 50 cm long, green initially, become white and develop numerous root hairs. Roots usually not anchored to substrate, although can root occasionally. Root systems intertwine with other frog-bit rosettes, creating an interconnected mass.

Leaves are leathery and round to hear-shaped. Flowers have three white petals and a yellow center.

Photo courtesy of Peter Zika, iNaturalist, www.inaturalist.org/observations/216129860.

Turion.

Photo courtesy of Lyudmila Mikh, iNaturalist, www.inaturalist.org/observations/236535280.

Spongy air pockets are easily visible on the underside of the leaf.

Photo courtesy of Brittany Killingbeck.

European Frog-Bit and its Lookalikes

	European Frog-Bit *(Hydrocharis morsus-ranae)* INVASIVE	Yellow-floating heart *(Nymphoides peltata)* INVASIVE	Little floatingheart *(Nymphoides cordata)* NATIVE
	 Photo courtesy of Wasyl Bakowsky.	 Photo courtesy of iNaturalist, www.inaturalist.org/observations/54725055, licensed under CC-BY-NC.	 Photo courtesy of Sean Blaney, iNaturalist, www.inaturalist.org/observations/130574872, licensed under CC-BY-NC.
Plant Type	• Floating, sometimes rooted	• Floating, rooted to sediment	• Floating, rooted to sediment
Leaves	• Rounded to heart-shaped • Smooth margins • 1.5 - 6.5 cm long • Green, underside purple red with spongy air pockets (aerenchyma) visible along the midvein	• Circular or heart-shaped • Slightly wavy margins • 3 - 15 cm long • Green to yellow-green, underside often purple, no visible aerenchyma	• Prominently heart-shaped • Smooth margins • 2.5 - 7.5 cm long • Green, mottled with red, underside purple red, no visible aerenchyma • Smooth leaf margins
Flowers/Fruit	• Small, white to pink with a yellow centre • **3 petals, 3 green sepals** • 2.5 - 6 cm in diameter • Flowers June-September • Fruit is a globose berry	• Bright yellow • Solitary or in clusters of 2 - 5 flowers • **5 petals that are fringed** • 2 - 4 cm diameter • Flowers May-October • Fruit is a beaked capsule	• White to cream-white with yellow centre • Solitary • **5 petals that are fringed** • < 1.5 cm diameter • Flowers April-August • Fruit is a spherical capsule
Roots	• Unbranched, up to 50 cm long, with numerous root hairs	• Stolons and rhizomes	• Not visibly present

Biology and Life Cycle

European frog-bit is an annual or short-lived perennial that reproduces primarily by vegetative means through stolon buds and turions. In the spring (late April to early May) turions break dormancy and float to the water surface to germinate. Throughout the summer, mature plants continue to send out stolons and rosettes continue to grow and expand. These stolons tangle with stolons of neighboring frog-bit plantlets, and free-floating roots together create dense mats of vegetation. In late summer and early fall, turions develop and break off as the plants begin to decay and then sink to the bottom. Turions overwinter for several months before rising to the surface in early spring and initiating growth. A single plant can produce 100 - 150 turions in a season, providing the potential for large overwintering biomass. Frog-bit also has the potential for rapid growth; from a single turion a plant may grow to cover an area of about 1 m^2 in only one season.

Habitat

European frog-bit generally grows in slow-moving water or in sheltered areas, such as inlets or larger lakes, ponds, slow-moving rivers and ditches. It can also be found in open marshes or wetlands floating on the water surface amongst cattails and other emergent grasses and rushes, which offer structural protection from harsh conditions.

Pathways of Spread

European frog-bit is frequently spread by plant fragments, stolons and turions that are inadvertently carried between waterbodies by boats, trailers and other aquatic equipment, or naturally when waterfowl transport plant parts on their feet while and after foraging. Given its attractive appearance, European frog-bit was historically used as an ornamental in water gardens and ponds, which acted as a pathway for spread. Although it is now against the law to import, deposit, release, breed/grow, buy, sell or trade this species in Ontario, it is possible that it may still be available illegally.. The improper disposal of plant material, which can be carried into nearby waterways during rain events or flooding, can also act as a source of invasion.

Distribution

Since its unintentional escape to the Rideau Canal in the 1930s, European frog-bit can be found throughout the St. Lawrence, Rideau and Ottawa River systems. Its range has extended to Point Pelee and Long Point marshes in Lake Erie, as well as Lake St. Clair, and it is found throughout the Kawartha Lakes and Trent-Severn Waterways. It has been documented in northwestern Ontario in Dinorwic and Eagle Lakes, and in scattered areas along the southern edge of the Canadian Shield. Outside of Ontario, it is found in Quebec and in the USA including the states of New York, Vermont, Wisconsin, Michigan and Washington. It has declined in parts of its native European range, such as the UK. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

European frog-bit is considered a significant invader of wetland habitats in Canada, due to its ability to grow rapidly and form large, densely tangled floating mats that crowd out native plants by blocking sunlight and reduce dissolved oxygen. When these dense mats die back and decompose in the fall, they decrease oxygen levels in the water, which can be lethal to fish and other aquatic organisms. Dense mats also impede recreational activities such as swimming, boating and fishing.

Control Measures

There are very few effective control methods for European frog-bit that lead to long-term eradication.

- Overall goal is to reduce the turion seed bank.
- Consider treatment timing: best in spring and mid-summer once rosettes are floating on the surface of the water, and before seeds and turions are produced in late summer and fall.
- Removing plants after turions are produced increases potential to promote spread to new areas.
- Most control methods must be conducted in the right timing window for fish spawning (typically after July 1st).
- Consider distribution and extent of spread.
- Small, isolated waterbodies: hand removal most effective, with minimal impact on non-target species. Can be used in combination with raking.
- Prevention of further spread to new areas is the best approach once populations are well established.
- Continue to monitor throughout spring and summer to remove plants that may have been missed in the initial efforts, or ones that have emerged later in the season.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (**page 6)** for details on how to report and prevent the spread of aquatic invasive plants.

Manual Control

Hand removal and raking are effective for individual plants or small populations.

Hand Pulling:

Focus on removing the buried turions and stolons, as well as the plant fragments that may break off. While wading into the water, handfuls of floating leaves can be collected, and placed into a floating raft and drifted to shore and deposited in a dry area far enough from the water. Hand pulling should be conducted after fish spawning (July 1st) but before the turions have a chance to break off in the fall and overwinter in the sediment. Repeat hand pulling biweekly throughout the summer for several years, to ensure adequate control. Be careful to properly clean equipment prior to moving elsewhere as the plant can easily spread by rakes, boots, equipment, and wave action.

Raking:

Raking can be combined with hand pulling to try and remove all plant fragments. For shallow waters where it is rooted, use a hard garden rake. For deeper waters where it is floating, use a soft leaf rake. Always start physical removal from the periphery of the population and work your way inward in a concentric fashion. Exercise caution as this method can potentially facilitate fragmentation and spread.

Cultural Control

Shading:

Shading can suppress growth and control spread for small, localized populations. This method is non-selective and can impact non-target submerged native plant species and macroinvertebrates. Not permitted in some water bodies (i.e., Trent-Severn Waterway or the Rideau Canal) and limited to small areas.

Biological Control

There are many organisms that use European frog-bit as a food source, such as insects, beavers and mice, water birds, freshwater snails and fish. Several potential agents for biocontrol have been identified, but to date none have been successful in controlling European frog-bit.

Chemical Control

There are no registered aquatic herbicides available for use on European frog-bit in Canada.

Control Techniques that are **NOT RECOMMENDED:**

- **Mechanical harvesting:** Not feasible as European frog-bit tends to grow in water that is too shallow for this type of removal.

See the Ontario Invasive Plant Council's Best Management Practices Guide on European Frog-bit **for more information on this invasive plant and control methods.**

European frog-bit has heart shaped leaves and a single white flower with a yellow centre.

Photo courtesy of Wasyl Bakowsky.

European lake sedge can grow to 1 m in height or more.
Photo courtesy of John Wilde.

European Lake Sedge
(Carex acutiformis)

Regulatory Status under Ontario's ISA: Not Regulated.

Introduction

Type of aquatic plant: Emergent, wetland plant (sedge).

Other names: Member of the Cyperaceae (Sedge) family, also known as lesser pond sedge and swamp sedge.

Area of origin, introduction date and location: Native to Eurasia and northern Africa, believed to have been introduced through contaminated hay that was imported from Europe. It was first discovered in Stony Swamp, near Ottawa, in 1987, and that is the only known occurrence in Canada to date.

Identification

Plant Type:

Emergent.

Size and Stem:

Large sedge. One to several stout stems arising from underground rhizomes. Stems are 0.5 - 1.2 m tall. Stems are triangular in cross-section, as is characteristic of sedges.

Leaves:

5.5 - 15 mm wide; M-shaped in cross-section. The leaves remain green longer into the fall and after frost, unlike most of our native sedge species.

Flowers:

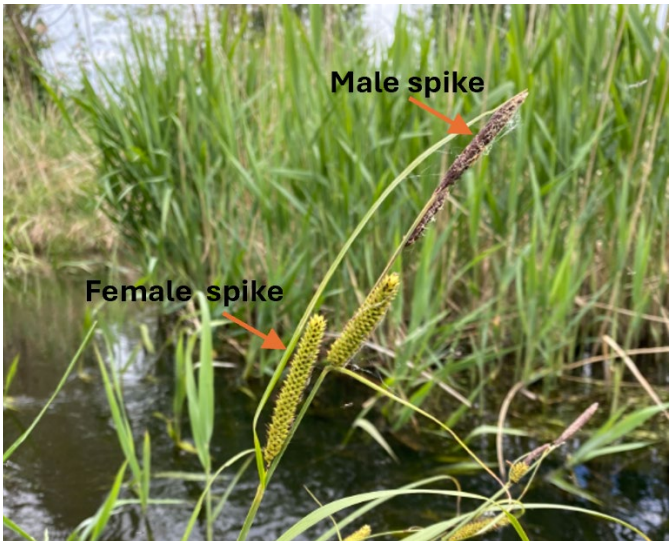
Distinctive among the *Carex* genus in possessing multiple flower spikes per stem, 3 stigmatic branches, and 3-sided fruits within a non-hairy sac (called the perigynium).

Fruits:

The female spikes produce structures called perigynia, which are sacs that enclose a single seeded fruit. The perigynium is shaped like a broad triangle and the surface is smooth (hairless) with 12 - 18 raised ridges or nerves (i.e., having simple but obvious veins); 3 - 4.5 mm long, with a beak 0.3 - 0.6 mm long, teeth 0.2 mm long. The beak at the end is less than ¼ the length of the perigynium. Fruits grow in a tight cylindrical cluster and are 3-sided. Fruiting occurs between June and August.

Roots:

Extensive root systems. Rhizomes are long-creeping.



There are multiple flower spikes per stem, male and female on separate spikes (male upper, female lower).

Photo courtesy of Molnar Abel Peter, iNaturalist, www.inaturalist.org/observations/209111491.

Fruits grow in a tight cylindrical cluster.

Photos courtesy of Molnar Abel Peter, iNaturalist, www.inaturalist.org/observations/209111491.

Leaves of European lake sedge are M-shaped in cross section.

Photo courtesy of Netarts Bay Today.

European Lake Sedge and its Lookalikes

European lake sedge can resemble several native sedge species, such as tussock sedge (*C. stricta*), water sedge (*C. aquatilis*), and lake sedge (*C. lacustris*). It differs from tussock sedge and water sedge in having strongly nerved perigynia, three-parted stigmas and three-sided fruits called achenes (instead of two-parted stigmas and two-sided lenticular fruits). It resembles lake sedge from a distance, but it has hairless and relatively short perigynia, with moderately broad leaves 5.5 - 15 mm wide. European lake sedge also remains green well into the fall.

	European Lake Sedge (*Carex acutiformis*) INVASIVE	**Water Sedge** (*Carex aquatilis*) NATIVE	**Lake Sedge** (*Carex lacustris*) NATIVE
	 Photo courtesy of Robert Ormston, iNaturalist, www.inaturalist.org/observations/189068024.	 Photo courtesy of Francois Rousseu, iNaturalist, www.inaturalist.org/observations/225846166.	 Photo courtesy of Riley Walsh, iNaturalist, www.inaturalist.org/observations/217939448.
Plant Type	• Emergent	• Emergent	• Emergent
Stalk	• Up to 1 m in height • Triangular at the base	• 30 - 150 cm • Smooth and triangular • Stems found solitary or together	• Erect, 50 - 150 cm • Rough to the touch and triangular • Purple or reddish at the base
Leaves	• 5.5 - 15 mm wide • M-shaped in cross section • Remain green longer in to the fall and after frost	• 4 - 7 mm wide • Bluish-white and hairless • Lower sheaths often red-tinged • Waxy appearance at tips	• Leaves as long as stem, 8 - 15 mm wide • Coarse, strongly “M” shaped in cross section • Blue-green in colour • Leaves disintegrate into ladder-like network of fibers
Flowers/Fruit	• 2 - 4 male spikes, 2 - 5 female spikes (3 - 8 cm x 7 mm) • Female spikes densely flowered • Perigynia 2.5 - 4.5 mm, with numerous raised veins • Flowering between June and August	• Elongate group of several, well separated spikes, 1.5 - 7 cm long, corn-cob like • Uppermost 2 - 3 spikes male, lower 3 - 5 spikes female • Perigynia 2 - 3 mm long, flattened, short beaked, nerved with 2 stigmas • Flowering July to August	• 4 - 8 well-separated spikes, • 2 - 4 male terminal spikes, 3 - 10 cm long, female spikes at base • Perigynia 4.7 - 7.3 mm long (average 6mm) with evidently raised veins, no hair, gradually tapering into a beak • Flowering between May and July

Biology and Life Cycle

European lake sedge reproduces through seed and vegetative means. Germination of seeds only occurs at temperatures above 15 °C, with peak emergence in early summer, and fruiting occurring between June and August. Based on populations in Europe, seed viability was fairly low relative to that of other local sedges, suggestive vegetative spread is favored. European lake sedge produces dense leaf growth, which results in more leaf litter than most other sedges. This may facilitate a higher rate of nutrient cycling, contributing to its extensive growth. It is often found growing in clumps, called "hummocks" found along the water's edge. The leaves remain green longer into the fall and after frost, unlike most of our native sedge species.

Habitat

European lake sedge can be found in a wide range of wetlands including swamps, marshes, open thickets, sedge meadows, and shorelines. At the Stony Swamp site, it grows in hummocks around open water up to 1 m deep as well adjacent drier sites.

Pathways of Spread

European lake sedge can be spread as a contaminant in hay. It fruits abundantly at Stony Swamp, and the perigynia could adhere to mammals such as beaver and muskrat or be ingested by waterfowl. As it occurs along a roadside ditch, there is potential for root masses and rhizomes to be spread by road maintenance vehicles. It does not appear to disperse well naturally across long distances.

Distribution

In Ontario, it has only been found in one location in Stony Swamp near Ottawa, where it dominates an area of about six acres. It has a very limited distribution in the northeastern and midwestern United States, with established populations in Indiana, Massachusetts, and Michigan, and collected specimens in Connecticut, Delaware, New York, and Rhode Island. There may be other populations in Canada and the US, but distribution is unclear due to its similarity to native sedges. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

European lake sedge's dense leaf biomass and extensive rhizome system effectively shades out other native plant species, making it an excellent competitor. At Stony Swamp, the European lake sedge invasion has displaced nearly all other native plants in a 6-acre open marsh area that once had a rich assemblage of native grasses, sedges, and forbs.

Although it is not yet spreading aggressively in North America, it has the potential to be a serious threat to native vegetation, due to its ability to spread rapidly by underground stems, creating dense monospecific stands. It is unusual among sedges in its high canopy and large leaf area, allowing it to outcompete native species for light and nutrients. Its leaf litter also decomposes slower than native sedge species, allowing it to smother native plants by accumulation of excess litter. The leaves remain green longer into the fall and after frost, unlike most of our native sedge species, giving it a competitive photosynthetic advantage. At Stony Swamp, some native butterflies have switched to using European lake sedge as a larval host plant. As it is difficult to distinguish European lake sedge from native sedges, there is potential for this species to spread undetected. Further, as the *Carex* genus is highly capable of hybridization between species, there could be a potential genetic threat to local native sedge species.

Control Measures

This plant is not yet well established in North America and information on management is lacking. If you think you see European lake sedge, particularly in a new location, take a picture, record the location and contact the Invading Species Hotline to report it. For more information and guidance call the **Invading Species Hotline at 1-800-563-7711** or visit www.invadingspecies.com or www.ontarioinvasiveplants.ca.

Refer to section Prevent the Spread (**page 6**) for details on how to report and prevent the spread of aquatic invasive plants.

Manual Control

Hand Pulling or Mechanical Harvesting:

Hand pulling or mechanical harvesting may be a viable option, depending on site conditions. Be careful to remove all parts of the root system and rhizomes to prevent further spread. Manual control is unlikely to eradicate populations but may help prevent population expansion. It is most effective if completed before seed production

Cultural Control

It has been suggested that European lake sedge may be controlled in wetlands by reduction in water level, but it is able to cope with low water levels and this is unlikely to be an effective form of control.

Biological Control

There are no known biological control agents for this species.

Chemical Control

There is no peer reviewed literature on the efficacy of herbicides against European lake sedge.

European lake sedge in Greenbelt, Ottawa.

Photo courtesy of Samuel Brinker, www.inaturalist.org/observations/53374184.

European water chestnut infestation at Voyageur Provincial Park.
Photo courtesy of Isabelle Simard.

European Water Chestnut
(Trapa natans)

Regulatory Status under Ontario's ISA: Prohibited Species.

It is illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade this prohibited invasive species in Ontario.

Introduction

Type of aquatic plant: Floating aquatic plant that roots in the sediment or floats freely in the water.

Other names: Jesuit's nut, water caltrop, devil's nut and death flower. It is commonly confused with the Chinese water chestnut (*Eleocharis dulcis*) used in Asian cuisine, however, they are unrelated. European water chestnut is a member of the Lythraceae (Loosestrife) family.

Area of origin, introduction date and location: Native to Europe and was introduced to the USA likely as a water garden plant in the mid 1800s. European water chestnut was first recorded in North America in 1859 in Massachusetts, in Canada in Quebec in 1998 and in Ontario in 2005.

Identification

Size and Stem:

Attached to a central stem and forms a densely crowded rosette. It can be up to 30 cm in diameter. The submerged portion of the stem grows up to 5 m, but is usually only 1 m long. The emergent portion is short and bears the rosette of leaves.

Leaves:

Heterophyllous (forms that occur above water (floating) and below water (submerged)). The floating leaves are leathery, typically triangular and up to 5 cm wide. They have serrated margins and the upper surface is covered in stiff hairs. The floating leaves have spongy petioles that allows the rosette float. The submerged leaves occur alternate along the stem, are finely divided can grow up to 15 cm long.

Flowers:

Small and white with four petals. They are produced in the axils of floating leaves on short stalks. Flowers are typically produced early to mid June.

Fruits:

Horned, nut-like structures (turbinate drupe) that is 3 - 4 cm wide. They have sharp barbed spines and a hard shell when mature.

Roots:

Slender and filamentous.

European water chestnut attaches to a central stem and forms a densely crowded rosette.

Photos courtesy of iNaturalist, www.inaturalist.org/observations/32086863.

Floating leaves (left) are leathery, and triangular and submerged leaves (right) are finely divided.

(Floating leaves) Andreas Berger, iNaturalist, www.inaturalist.org/observations/225697520.
(Submerged leaves), Umar Musa, iNaturalist, www.inaturalist.org/observations/149482404.

The flowers of European water chestnut are small, white and have four petals.

Photo courtesy of Irina Mitjushina, iNaturalist, www.inaturalist.org/observations/89901477.

The fruits of European water chestnut are horned, nut-like structures.

Photo courtesy of V.S. Volkotrub, iNaturalist, www.inaturalist.org/observations/22226072.
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European Water Chestnut and its Lookalikes

European water chestnut is a very distinctive plant and does not have any lookalikes in Ontario.

Biology and Life Cycle

European water chestnut is an annual plant that overwinters as a seed. The seeds germinate in early spring when water temperatures reach 8 - 15 °C. Growth of the plant is temperature dependent. Plants reach the water's surface in May or early June, where the floating rosettes are formed. Flowers are produced in July and are typically pollinated by insects but are also capable of self-pollination. One rosette can produce up to 20 seeds. Mature seeds are released into the water approximately one month after pollination. Flowers and seeds are continuously produced until the first frost, usually in October. When mature, the seeds fall from the plant and sink to the bottom of the waterbody. Seeds can remain dormant for 8 to 10 years but usually germinate within two years. This plant can also reproduce via ramets (genetically identical clones) that can detach, allowing for rapid expansion.

Habitat

European water chestnut grows most often in quiet, nutrient-rich, slow-moving waters. It can tolerate a pH range of 6.7 - 8.2. Its preferred habitat is the muddy shorelines of lakes, slow rivers and ponds. It prefers full sun and soft substrate (such as mud), and it usually occurs in waters up to 2 m deep, but can be found in water up to 4 m deep. It is considered disturbance-tolerant and can be found in sewage intake waters and can tolerate salinity.

Pathways of Spread

European water chestnut has been historically valued as an ornamental plant for water gardens and as a food crop. While it is illegal to buy or plant this species in Ontario as per the ISA (2015), most wild populations result from the intentional planting of this species. It may be intentionally planted along shorelines and escape into new areas as plant material is discarded into a waterway, or it may be carried away by flooding during a rain event. Most spread happens from seed carried by wind or strong currents by attaching to equipment, boats and trailers or by waterfowl and mammals. The barbed spines of the seeds may hook onto passing objects such as animals and nets and detach easily after the barb weakens.

Distribution

In Ontario, European water chestnut has been found in Lake Ontario's Bayfield bay (St. Lawrence river) (2014), in Rideau Canal (Ottawa) (2014) and Greater Cataraqui River (Kingston). In Canada, it also occurs in southwestern Quebec where it has been the focus of an eradication program since 2002. There are reports of this plant in northeastern United States (Lake Champlain watershed) in New York and Vermont, as well as in Lake Ontario on the New York side. It is also found in isolated populations in Kentucky, West Virginia, Virginia, New Jersey, Maryland and Delaware. It is also invasive in Australia. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

European water chestnut forms dense floating mats of vegetation that can outcompete submerged and emergent native aquatic vegetation, including those needed as a food source for waterfowl. The plants die in the fall, leaving a thick layer or detritus that can cause waterbodies to become anoxic (low oxygen) which can cause significant mortality in fish populations. As a result of its dense growth form, it can decrease light penetration which can negatively impact other aquatic organisms. The seeds have very sharp spines that can inflict injuries to swimmers and other recreationists. It can inhibit recreational activities such as boating, angling or swimming. It also becomes extremely costly to control once established.

Control Measures

It is much easier and less expensive to control new or small populations of European water chestnut. As such, early detection and rapid response are key to prevent established infestation. Refer to section Prevent the Spread (**page 6**) for details on how to report and prevent the spread of aquatic invasive plants.

Control of European water chestnut is most effective when measures are undertaken as soon as a population has been identified, ideally within one year. Once a population is established, European water chestnut requires significant resources and effort for 10 to 15 years to exhaust the seed bank. The best window for control is mid-June to mid-August, after the seeds are formed but before they mature. Since this plant is an annual, successful eradication depends on removing the rosettes before they go to seed. The target of control is to reduce plant numbers, prevent seed production and exhaust the seed bank. European water chestnut is rarely eradicated after one season. Monitoring and re-assessment of control measures are key to effective control of this species.

It is important to note that European water chestnut is regulated as a prohibited species under the *Invasive Species Act* (ISA). It is currently illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade this species. In order to support the effective management of this species across the province, the Ministry of Natural Resources has developed a Prevention and Response Plan for European Water Chestnut in Ontario. The Prevention and Response Plan enables people and organizations to undertake low risk activities to monitor, control, and in some cases eradicate, this invasive plant without the need for an authorization under the ISA (2015). This prevention and response plan identifies the persons or groups of persons who are authorized to implement the plan, sets out the types of activities that the plan applies to and describes conditions that these persons must follow to lawfully possess, transport, and deposit European water chestnut in Ontario. The plans also include detailed best management practices for this invasive plant. Individuals planning to undertake activities to monitor or control this species should familiarize themselves with the rules and conditions outlined in the Prevention and Response plan in order to understand whether an authorization under the ISA (2015) may be required.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to report and prevent the spread of aquatic invasive plants.

Manual Control

Hand Removal:

Individual plants or small populations of European water chestnut can be successfully harvested by hand. Start at the edge of infestation and work inwards. Hand protection should be worn to avoid contact and injury with the sharp, barbed spines of the seed. Volunteers and staff at Voyageur Provincial Park have pulled plants by wading into the water or by using canoes, kayaks and boats to access plants. Hand pulling is a simple method but can be time and labour intensive. Caution must be taken to remove all parts of the plant. Rooted plans can resprout if only the top part of the plant is removed. Plants should be turned upside down immediately after being pulled to prevent any seeds from dropping. Plants should be composted and disposed of on land, in a secure location to prevent dispersal of seeds. This should be done before the plants produce seeds (mid-June to early July) as they can easily fall off the parent plant and contribute to the seedbank. Revisit the site throughout the growing season to remove any regrowth.

Raking:

Raking can be effective because most or all of the plant can be removed. Even so, raked areas should be revisited regularly to remove any missed plants. Raking is most effective for small and sparsely infested areas. Raked plants must be completely removed from the water, to prevent uprooted plants from floating downstream and spreading the seeds.

Mechanical Control

Mechanical Harvesting:

Mechanical harvesting involves using equipment such as a cutter boat to cut through the stems and loading the rosettes on to a boat or pushing them towards the shore to decompose. This is effective for large infestations and is where equipment can operate in shallow waters and maneuverable enough to avoid obstacle to remove dense mats of vegetation. In Voyageur Provincial Park a cutter boat cuts the rosettes approximately 6" below the water surface and a collector boat pushes them into shore for composting. Harvesting should take place before seeds mature and drop, to break the reproductive cycle of the plant. This control measure must be repeated for several seasons to exhaust the seed bank. Extreme care must be taken to avoid the unintentional spread of floating plant parts. This should be done before the plants produce seeds (mid-June to early July) as they can easily fall off the parent plant and contribute to the seedbank. Note that the Prevention and Response Plan for European Water Chestnut does not apply to the use of removal activities other than by hand pulling or other human-powered hand-held devices (e.g., rake). Persons seeking to remove European water chestnut through the use of mechanical harvesters must obtain a separate authorization under the ISA (2015).

Cultural Control

There are no cultural controls available for European water chestnut.

Biological Control

There are currently no approved biocontrol agents for European water chestnut in North America.

Chemical Control

Large and established infestations of European water chestnut can be controlled using herbicides. However, due to the potential impacts to non-target species, chemical control should be considered a last resort. A few diquat-based and florpyrauxifen-based herbicides are registered for European water chestnut control in Canada. Herbicide application should take place before the seeds mature and drop, to break the reproductive cycle of the plant. Several years of treatment are typically necessary to kill seedlings.

Leaves of European water chestnut are triangular and sharply toothed, forming a crowded rosette.

Photo courtesy of Ontario Federation of Anglers and Hunters.

Eurasian water-milfoil forms a dense canopy at or just below, the water's surface.

Photo courtesy of Alison Fox, University of Florida, Bugwood.org.

Eurasian Water-milfoil (*Myriophyllum spicatum*) and Eurasian and Northern Milfoil Hybrid (*Myriophyllum spicatum* × *M. sibiricum*)

Eurasian water-milfoil status Ontario ISA (2015): Restricted.

Eurasian and northern milfoil hybrid status Ontario ISA (2015): Not listed.

It is illegal to import, deposit, release, breed/grow, buy, sell, lease or trade this restricted invasive species in Ontario. It is also illegal to bring a restricted species into a provincial park or conservation reserve and to possess, transport, deposit or release them in these protected areas.

Introduction

Type of aquatic plant: Submerged, aquatic plant.

Other names: Member of the Haloragaceae (Water-milfoil) family.

Area of origin, introduction date and location: Eurasian water-milfoil is native to Europe, Asia and northern Africa and was probably introduced to North America through the aquarium trade, or in ballast water from shipping in the 1940s. The first record in Canada was from Lake Erie in 1961. The Eurasian and northern milfoil hybrid (*Myriophyllum spicatum* × *M. sibiricum*) is formed when Eurasian water-milfoil (invasive) and northern water-milfoil (native) hybridize where they are present in the same waterbody.

Identification

Plant Type:

Submerged.

Size and Stem:

Submerged; in water depths between 1 - 4 m, up to a depth of 10 m. Once the plant reaches the water surface it branches extensively, forming dense canopies. Stem is a leafy shoot, can be long and spaghetti-like (0.5 - 7 m long), branching at water surface. Tip of the stem usually reddish and thin, getting thicker below the flowers.

Leaves:

Whorled, green, feather-like. Whorls (circles) are centered around nodes along the stem, with 3 - 6 (typically 4) leaves per node. Each leaf has 12 - 24 filiform or threadlike divisions.

Flowers:

Emergent, grow on terminal spikes above the water. Arranged in whorls (circles) around spike, pink-red hue, 5 - 20 cm long. Flowers from late July to early August; upper flowers are male, the lower flowers are female.

Fruits:

Red, berry-like.

Roots:

Can be rooted or unrooted to sediment. No overwintering structures (turions). Small buds may be present and develop from a single root, initially at the base.

Whorls of 3 - 6 (typically 4) leaves around each node. The tip of the stem is reddish in colour.

Photo courtesy of John-Pierre Thonney.

Leaves are feather-like with 12 - 24 filiform or threadlike divisions.

Photo courtesy of Aaron Gunner, iNaturalist, www.inaturalist.org/observations/15997885.

Flowers are arranged in whorls on a terminal spike that is borne above the water surface.

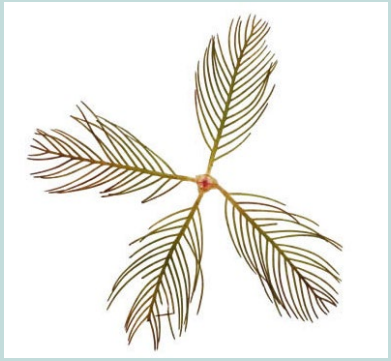
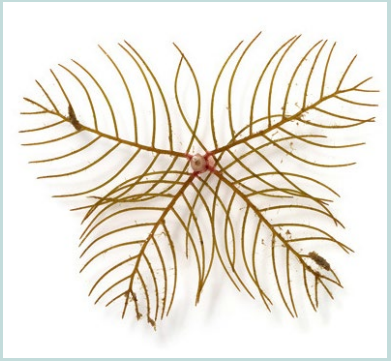
Photo courtesy of iNaturalist, www.inaturalist.org/observations/239342579.

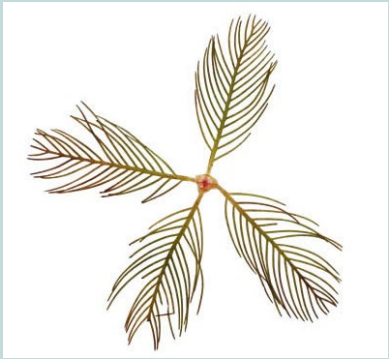
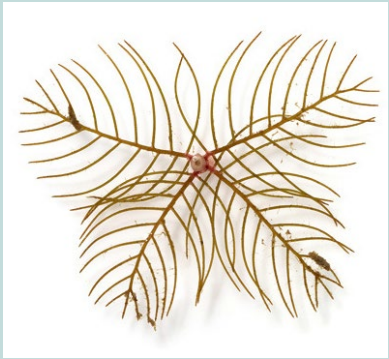
Flowers have a pink-red hue.

Photo courtesy of Holly Young, iNaturalist, www.inaturalist.org/observations/182031654. Licensed under CC-BY-NC.

Eurasian Water-milfoil and its Lookalikes

Differentiating between Eurasian water-milfoil can be very difficult, as there is considerable overlap in traits, including the number of pairs of leaflets on each leaf. The most reliable method of identifying any milfoil species is through molecular testing using the plant's DNA.

	Eurasian Water-Milfoil *(Myriophyllum spicatum)* INVASIVE	**Hybrid Water-Milfoil** *(Myriophyllum spicatum × M. sibiricum)* INVASIVE	**Northern Water-Milfoil** *(Myriophyllum sibiricum)* NATIVE
	 Photo courtesy of Fero Bednar (www.wnp.sk), iNaturalist, www.inaturalist.org/observations/133132060.		 Photo courtesy of Fero Bednar (www.wnp.sk), iNaturalist, www.inaturalist.org/observations/133132060.
Plant Type	Submerged	Submerged	Submerged
Stem	• **0.5 - 7 m long** • Leafy shoot, many branches • Stem tips usually reddish; stem diameter double in width immediately below the terminal spike	• **0.5 - 7 m long** • Leafy shoot, sparsely branched • Stem tips usually green, can be red in some spots; stem diameter immediately below the terminal spike is the same as lower stem	• **0.5 - 3 m long** • Leafy shoot, branching repeatedly **(tends to branch more than Eurasian and northern water-milfoil)** • Stem diameter can vary
Leaves	• Arranged in whorls of 3 - 6 (usually 4), feather-like, pinnately divided, with **greater than 12 threadlike divisions per leaf (usually 12 - 20)** • Leaves are limp when out of water	• Arranged in whorls of 3 - 6 (usually 4), feather-like, pinnately divided, with **less than 11 threadlike divisions per leaf (usually 5 - 11)** • Leaves are usually rigid out of water	• Arranged in whorls of 4 - 6, feather-like, pinnately divided, **with varying number of threadlike divisions per leaf**

	Eurasian Water-Milfoil *(Myriophyllum spicatum)* INVASIVE	Hybrid Water-Milfoil *(Myriophyllum spicatum × M. sibiricum)* INVASIVE	Northern Water-Milfoil *(Myriophyllum sibiricum)* NATIVE
	 Photo courtesy of Fero Bednar (www.wnp.sk), iNaturalist, www.inaturalist.org/observations/133132060.		 Photo courtesy of Fero Bednar (www.wnp.sk), iNaturalist, www.inaturalist.org/observations/133132060.
Flowers/Fruit	• Emergent, on terminal spike above water, **5 - 20 cm long** • Upper flowers male and lower flowers female • Pink or white (frequently white) arranged in whorls; flowers larger than bracts; bracts have smooth margins • Flowers between late July and early August	• Emergent, on terminal spike above water, **4 - 15 cm long** • Upper flowers male and lower flowers female • Pink • Arranged in whorls; flowers small; bracts equal to or slightly longer than female flowers and have serrated margins • Flowers between late July and early August	• Flowers and fruit can look like a combination of both parent plants, or like either parent plant • Flowering frequently throughout growing season
Turions	• Does not form winter buds (turions)	• Does form winter buds (has turions), towards the end of the growing season. Egg-shaped and form along submerged stems	• Can appear with or without winter buds (turions)

Biology and Life Cycle

Eurasian water-milfoil can spread sexually by seed as well as vegetatively through stem fragmentation and stolon growth. In the Great Lakes region, Eurasian water-milfoil begins to break dormancy in early spring before other native macrophytes and initiates growth as water temperatures approach 15 °C.

Flowering spikes emerge above the water line once the plant has reached the surface, typically June to July. Fruits develop later in July or August and continue until September. The plant reaches its peak growth and biomass shortly after flowering, when milfoil stems begin to branch and form dense clusters, blocking available sunlight to other submerged plants. Soon after this peak biomass in late summer to early fall the plant begins a natural process called autofragmentation, whereby small branches begin to develop roots, break away from the parent plant, and float until they lose buoyancy, at which point they sink and root in the sediment, ultimately forming new plants. Towards the end of the growing season, some plants die back to their root crowns, while others overwinter intact in an evergreen form. Unlike other species of water-milfoil, Eurasian water-milfoil lacks specialized structures called turions, which are overwintering buds that store starch to be used for growth. Reserves are stored instead in overwintering roots and shoots.

Habitat

Eurasian water-milfoil is most commonly found in slow or stagnant waters, such as ponds, marshes, lakes with little disturbance, or along sheltered portions of streams (i.e., coves, inlets). It is able to rapidly colonize areas that have experienced some form of disturbance; disturbance can result in fragmentation and spread.

It is most common in depths of 1 - 3 m but can grow up to depths of 10 m. In shallow water (less than 1 m), growth is restricted, likely due to greater fluctuations in water levels and temperature. The depth and clarity of the water determines the rooting depth and growth form of the plant. In shallower and more turbid waters, plants have shallower rooting depths, with horizontal stems at the surface that tend to mat profusely. In deeper and clearer waters, milfoil grows to deeper depths and is able to grow into long strands and will not reach the surface or form dense canopy stands.

It has been described as a "well-adapted plant" which can grow in a variety of environmental conditions, including nutrient rich (*eutrophic*) and low nutrient (*oligotrophic*) waters. It has a wide pH tolerance (pH 5.4 - 11), although growth is most optimal in alkaline waters. It can also grow over a broad temperature range (15 - 35 °C).

Pathways of Spread

Eurasian water-milfoil spreads between waterbodies via plant fragments, which can be transported long distances by boats, boat trailers, fishing gear, and other aquatic equipment, as well as naturally by water currents, wind and waterfowl, as well as autofragmentation. Once established, it can spread to connected waterbodies and through canals such as the Trent-Severn Waterway. This is why it is critical to follow the rules and best management practices for cleaning watercraft and watercraft equipment when boating in waterbodies where Eurasian water-milfoil is present.

Whorls of leaves occur at nodes along stem, 1 to 3 cm apart.

Photo courtesy of Graves Lovell, Alabama Department of Conservation and Natural Resources, Bugwood.org.

Distribution

In Ontario, Eurasian water-milfoil has spread through the Great Lakes, southern and eastern Ontario, to coastal Georgian Bay. It is most notable in the inland lakes in southern Ontario, including the Kawartha Lakes region of the Trent-Severn Waterway, as well as the Rideau Lakes system and the Greater Sudbury Area. It is also found in Quebec, the St. Lawrence River System, New Brunswick, Prince Edward Island, Manitoba and British Columbia. It is widespread throughout most of the United States and has spread across every continent except Antarctica.

The hybrid water-milfoil is not widely tracked and is difficult to differentiate from the parent plants. However, it is known to be present in Ontario in the Great Lakes and the Kawartha Lakes and in British Columbia. It has also been found in almost every United States state that has Eurasian water-milfoil, including Wisconsin, Minnesota, Oregon, Washington, Idaho, Michigan and Vermont.

For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Eurasian water-milfoil forms a dense canopy at the surface of the water or just below, which impedes recreational activities such as angling, boating and swimming. It can also affect water flow and contribute to flooding. Excessive growth suppresses native plant and animal diversity. Eurasian water-milfoil forms dense floating mats of vegetation that can outcompete native aquatic plants and can alter a lake's natural ecosystem. Dense mats block available light and impact water clarity, and its extensive root system reduces space and access to nutrients in the sediment for other plant species. A decline in native plant species richness and abundance leads to reduced macroinvertebrate abundance, altered habitat structure, and negatively impacts fish populations.

Thick beds also create stagnant conditions, which alter water quality and reduce dissolved oxygen levels, a situation that can be lethal to fish. Sensitive fish species such as salmonids are particularly impacted by Eurasian water-milfoil, as thick beds reduce spawning success by covering suitable open gravel areas for spawning. In addition, reduced oxygen levels caused by the decomposition of plant matter can kill fish and contribute to algal blooms.

Dense stands of Eurasian water-milfoil can also impact recreational activities such as boating, swimming and angling. Thick mats are considered unsightly and decrease the aesthetic value of beachfront properties, creating stagnant conditions ideal for mosquitos. Several studies in the USA have demonstrated that Eurasian watermilfoil can significantly reduce lakefront property values. Excessive growth can also clog industrial and power generation water intakes and restrict the operation of flow metering devices in flood control channels.

Hybrid milfoil expresses a trait called hybrid vigor, which is the expression of superior qualities of both parents. It has faster growth rates than its parent plant and can out-compete them and other native plants for space and sunlight and is regarded as an invasive plant.

Control Measures

Control of Eurasian or hybrid water-milfoil is most effective when an integrated pest management approach is applied, that combines education and prevention strategies with multiple control methods.

Management approaches can help reduce milfoil biomass in the short term (weeks to a few years) but will not completely eradicate populations.

Due to its ability to fragment and re-root, physical removal methods can facilitate spread if containment measures are not undertaken.

Floating booms can help prevent spread by suspending curtains in the water to capture plant fragments where water flow is minimal. Note that any left-over plant material will regrow regardless of control type, therefore extra care should be taken to remove all plant pieces.

Control ideally should begin by mid- to late June, when the native seed bank has had a chance to establish and effectively compete with Eurasian water-milfoil. Control can also be timed during carbohydrate storage low points (May-July), which can help maximize treatment efficacy by limiting growth post-treatment, particularly for chemical and manual control.

Be aware of the impacts control methods might have on macroinvertebrates and fish species that may be using milfoil and other plants as shelter. Controlling too late in the season should also be avoided as in the fall (September-October), Eurasian water-milfoil becomes brittle and can fragment easily.

Since hybrid water-milfoil may re-grow more quickly after control is conducted, control may need to be conducted more frequently during the growing season.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (**page 6**) for details on how to report and prevent the spread of aquatic invasive plants.

Manual Control

Hand Pulling

Hand pulling individual plants, small population or isolated water bodies can prevent spread. When hand pulling, focus on removing all fragments that may break off during removal. Fragments that are left behind can root in the sediment and grow new plants. Continue to regularly monitor the site for several years for new plants growing from roots or plant fragments. The plant can be removed by snorkeling in shallow water or scuba diving and works best when paired with a partner on a raft who can observe plant fragments, collect pulled plants and watch for hazards. Continue to monitor and remove plant material throughout the summer. Best after fish spawning (July 1st) and before fall when milfoil becomes more brittle.

Raking:

Raking can be effective in maintaining open water around docks or swimming areas, but is not effective for large areas. Raking can help remove plant material, but it will not eliminate the plant, and in most cases will spread the plant via fragments. In deeper water, raking may be combined with hand pulling to try and remove all floating plant fragments. Plants can also be pulled using a rake by guiding the rake along the plant and spinning the rake so the stems are wrapped around the rake before pulling it up from the water.

Mechanical Control

Mechanical Harvesting:

Mechanical harvesting is only recommended for large areas where Eurasian water-milfoil has become widespread and needs to be cleared for navigation purposes or safety concerns. It is only recommended when other control measures cannot be used. Harvesters involve a machine that cuts milfoil at a certain depth below the water's surface and bundles the plant material for removal and transport. Cut material is either transported directly to a conveyer belt and stored on the harvester for later disposal or floats on the surface and is raked up by a trailing machine. As a non-

selective control measure, harvesting will indirectly harvest other plant, fish, and macroinvertebrate species. It can also fragment rhizome pieces, contributing to further spread.

Dredging or Suction Harvesting:

In suction dredge harvesting, divers remove whole milfoil plants (stems, roots, leaves) from the substrate using a dredge hose connected to an industrial engine that creates suction. This method is best for small areas within larger waterbodies. Harvesting is disruptive as it is non-selective, can impact water quality, promote algal blooms, and cause milfoil to return at faster rate due to nutrient release during dredging and aeration of the bottom.

Cultural Control

Benthic Barriers:

Benthic barriers, benthic mats or bottom screens can control growth in localized areas, such as around boat launches, docks and/or swimming areas, as part of an IPM strategy. When left in the water, mats will accumulate sediments, allowing new plants to root on top of them which essentially buries the milfoil and it decomposes. However, this method is considered low efficacy as it is expensive, difficult to install, laborious, non-selective, and requires routine monitoring and maintenance throughout the growing season. Consider transplanting species onto the treated area in order to reduce the potential for milfoil or another nuisance species such as algae from taking over. Regulatory restrictions must also be considered. Benthic barriers are not permitted by Parks Canada for use in the Trent-Severn Waterway or the Rideau Canal. For projects on Provincial Crown Land and shore lands, placement of these materials requires a work permit from MNR under the *Public Lands Act*; they do not fall under the provincial rules for removing invasive or native aquatic vegetation in Ontario.

Water-level control:

Drawing down the water level can only be conducted in areas where the water levels are controllable. It is not a possibility for public waters but could be used in small landlocked ponds. For this control measure to be effective, water levels must be lowered in the winter to expose the root crowns to freezing temperatures. If exposure is not long enough, the control measure will not be effective.

Biological Control

The North American weevil (*Euhrychiopsis lecontei*) has been used as a biological control for Eurasian water-milfoil and hybrid water-milfoil. The adults feed on the stems and leaves of the plant, while the larvae bore into and feed on the inside of the stem, thus causing the plant to lose buoyancy and sink. However, for this method to be successful weevil densities must be high enough to significantly impact milfoil density, requiring continual restocking of beetles to ensure adequate numbers. Unfortunately, past attempts at weevil release in parts of Ontario such as Big Cedar Lake and lakes in the Sudbury area resulted in initial declines in milfoil, but densities of beetles were not high enough to cause significant damage, even with augmentation.

Chemical Control

Diquat is a broad-spectrum contact herbicide available in Canada as a restricted herbicide. It is applied to submerged aquatic vegetation via the water column and can be greatly affected by various water exchange processes that may dilute concentrations. It is effective and fast-acting, requiring only a short exposure time, however as a non-selective herbicide diquat can harm many non-target species. It has lethal effects on invertebrate species using aquatic plants for cover. In addition, plant dieback can lead to problems with dissolved oxygen and eutrophication. Areas

that have been treated cannot be used for human recreation or consumption for at least five days.

A newly registered herbicide called ProcellaCOR (PCPA Registration No. 34732) has been piloted in a few Ontario lakes to control milfoil. This herbicide more selectively targets Eurasian water-milfoil and may be a viable alternative to diquat in the future.

See the Ontario Invasive Plant Council's Best Management Practices Guide on Eurasian Water-milfoil **for more information this invasive plant and control methods.**

Eurasian water-milfoil can spread by disturbance such as boating activities.

Photo courtesy of Matt Vardy, Ontario Federation of Anglers and Hunters.

Dense mat of fanwort.

Photo courtesy of Sam Brinker.

Fanwort
(Cabomba caroliniana)

Regulatory Status under Ontario's ISA: Restricted Species.

It is illegal to import, deposit, release, breed/grow, buy, sell, lease or trade this restricted invasive species in Ontario. It is also illegal to bring a restricted species into a provincial park or conservation reserve and to possess, transport, deposit or release them in these protected areas.

Introduction

Type of aquatic plant: Submerged, aquatic plant.

Other names: It is a member of the Cabombaceae (Water-shield) family and is commonly known as "Cabomba" or Carolina fanwort in the aquarium and water garden trade.

Area of origin, introduction date and location: Native to the subtropic and temperate regions of South America. Fanwort's native range extends from Southern Brazil and North-Eastern Argentina into the Southern United States. It was first recorded in North America in 1920 and first reported in Ontario in 1991 after a sighting in Kasshabog Lake, north of Peterborough. Since then, it has also been identified in the Crowe River which flows out of Kasshabog Lake and it is now as far downstream as Round Lake. There are a few isolated populations in Nova Scotia.

Identification

Size and Stem:

Fanwort grows underwater, rooted in the sediment and can grow up to 2 m in length.

Leaves:

Heterophyllous (forms that occur above water (floating) and below water (submerged)). Floating leaves (if produced) are small, linear to diamond shape (1 cm long) with smooth margins and occur alternate along the stem. They have short to long petioles and are borne on flowering branches. The submerged leaves are finely dissected, fan-shaped (< 6 cm wide) and have distinct petioles (4 cm long).

Flowers:

Typically emergent (occurring above the surface of the water) but are occasionally submerged. They are borne singly at the tips of stems, measure 2 cm across, with three sepals and three petals. They have a yellow centre and range in color from white to pale yellow but can also include a pink or purplish tinge on the margins. They flower anytime between mid-summer and early fall and appear among the floating leaves.

Fruits:

The fruits of fanwort are flask shaped, leathery, 3-sided follicle.

Roots:

Slender and anchor the plant into the sediment.

Fanwort is a submerged aquatic plant that can grow up to 2 m in length.

Photo courtesy of Eric Keith, iNaturalist, www.inaturalist.org/observations/141320556.

Floating leaves (left) are small, linear to diamond shape, submerged leaves (right) are finely divided and fan-shaped.

Photos courtesy of (Floating leaves) Russell Cumming, iNaturalist www.inaturalist.org/observations/106482865, (Submerged leaves) iNaturalist, www.inaturalist.org/observations/14190171.

The flowers of fanwort are typically emergent, small, white with three sepals and three petals.

Photos courtesy of Dave Wetzel, iNaturalist, www.inaturalist.org/observations/34240550 and iNaturalist, www.inaturalist.org/observations/155124390. All images licensed under CC-BY-NC.

Fanwort and its Lookalikes

Fanwort has many other similar looking species, however, only fanwort has opposite, finely dissected, fan-shaped leaves on distinct petioles (additional lookalikes include Northern water-milfoil (*Myriophyllum sibiricum*), coontail (*Ceratophyllum demersum*) and white water crowfoot (*Ranunculus aquatilis*)).

	Fanwort *(Cabomba caroliniana)* INVASIVE	**Common Bladderwort** *(Utricularia vulgaris)* NATIVE	**Water-Marigold** *(Bidens beckii)* NATIVE
	 Photo courtesy of Graves Lovell, Alabama Department of Conservation and Natural Resources, Bugwood.org.	 Photo courtesy of Wikimedia Commons, 2014.	 Photo courtesy of Maine Lake Volunteers, 2014.
Plant Type	• Submerged	• Floating/submerged	• Submerged
Stalk	• Up to 2 m long • Branched, **green-reddish, with white or reddish-brown hairs**	• Up to 0.3 m long • Few-branched, green-reddish, **zig-zag appearance**	• Up to 7 m long • Hairless, thicker below water surface
Leaves	• Submerged leaves are **opposite, finely dissected, fan-shaped (< 6 cm wide) and have distinct petioles (4 cm long)** • Floating leaves (if produced) are small, linear to diamond shape (1 cm long) with smooth margins and occur alternate along the stem. They have short to long petioles and are borne on flowering branches	• Submerged leaves alternate, but leaves may appear to occur in pairs, up to 5 cm long • 1 or 2 main divisions main divisions from the base, finely divided into thread-like segments, **many bladder-like traps scattered among leaflets**	• Submerged leaves finely dissected into threadlike segments, 2 - 4 cm long • **Floating leaves opposite, lance to egg-shaped,** smooth or sharply toothed margins, 2 - 4 cm long

	Fanwort *(Cabomba caroliniana)* INVASIVE	Common Bladderwort *(Utricularia vulgaris)* NATIVE	Water-Marigold *(Bidens beckii)* NATIVE
	 Photo courtesy of Graves Lovell, Alabama Department of Conservation and Natural Resources, Bugwood.org.	 Photo courtesy of Wikimedia Commons, 2014.	 Photo courtesy of Maine Lake Volunteers, 2014.
Flowers/Fruit	• Typically emergent or occasionally submerged • Small, 2 cm wide, on long stalk, borne singly • **3 sepals, 3 petals, white to pale yellow, may include pink-purple tinge, yellow centre** • Appear late spring/early fall • **Fruit is flask shaped, leathery, 3-sided follicle**	• Emergent • 1 - 2 cm long, **borne in a raceme (cluster) or 4 - 20 flowers** • **Flowers resemble snapdragon and emerge on stalks above surface** • Flowers throughout summer • **Fruit is a round capsule,** 2 cm diameter	• Emergent • 3 - 5 cm wide, on a long stalk, borne singly, **head inflorescence.** • **6 - 10 golden-yellow ray flower, centre made up of 10 - 30 yellow disc flowers** • Flower late summer • **Fruit are rounded,** 3 - 6 cm with **long bristles barbed near tips**

Submerged leaves are on petioles 15 mm in length.

Photo courtesy of Robert Vidéki, Doronicum Kft., Bugwood.org.

Biology and Life Cycle

Fanwort is considered a perennial plant which predominantly reproduces through fragmentation. While seeds are produced, they have very low viability. In the spring, new growth emerges from roots buried in the sediment and from over-wintering stem fragments. In Ontario, the plant emerges late, after the native plant community. It reaches its maximum height in late July to early August, and continues to grow until it fully occupies the water column. Its full growth potential is not reached until October. In the fall, the tops of rooted plants defoliate, becoming brittle and breaking part which leads to dispersal via fragmentation. Disturbance from natural or human activity causes the mats of fanwort to break up. A free-floating fragment with a single node (i.e., the portion of the stem where leaves attach) has a 30 % chance of regenerating and when in substrate. Plant fragments are capable of spreading, rooting in the sediment and producing new plants.

Habitat

Fanwort can tolerate a wide range of environmental conditions. It is typically found in silty sediment, in stagnant, quiet or slow-moving waters. It can also be found growing in sand, mud or gravel sediment. It has wide pH tolerance (5.7 - 9.2) and can tolerate anoxic and poor water quality. It is found in water up to 10 m in depth, but grows best in 1 - 2 m. It prefers to grow in lakes, streams, rivers, ponds or ditches that are acidic (low pH) or have a granite base (Canadian Shield lakes). Shield lakes are less generally diverse and less abundant in native aquatic vegetation, so may be more vulnerable to invasion.

Pathways of Spread

Fanwort is commonly sold in the aquarium and water garden trade and, while now illegal to import, possess, transport, deposit, release, propagate, buy, sell or trade, may still be available illegally in Ontario. It may be released into the environment through improper disposal of aquarium contents, carried into nearby waterways during rain events through flooding, or even through intentional plantings. It can also spread between waterbodies through plant fragments that attach to boats, boat trailers, and other equipment, such as fishing gear, For this reason, it is critical to follow the rules and best management practices for cleaning watercraft and watercraft equipment when boating in waterbodies where fanwort is present. Range expansion is linked to introduced populations rather than from commercial source populations.

Distribution

In Ontario, fanwort is currently only in the Crowe River Watershed starting from Kasshabog Lake and as far downstream as Round Lake as of 2022. There have been a few isolated sightings in Nova Scotia. In the United States, it is found in the northeast states including New Hampshire, New York, Massachusetts, Rhode Island, the southern states (where it may be a native species) and the west coast states including California, Oregon and Washington. It has also been reported invasive in Australia, India, Japan, South Africa and Malaysia. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Fanwort can form dense mats that outcompete native vegetation and lower diversity. These dense mats also lower the amount of light that penetrates water which can alter invertebrate assemblages. This can also lead to significant decreases in water quality including a reduction in dissolved oxygen which can lead to fish death. Dense mats also impact recreational activities such as boating, fishing and swimming. In more southern temperate areas, where its growth is continuous throughout the year, it can reduce

water storage capacity (which may result in flooding) and taint drinking water sources with plant fragments. Because it prefers environments that have a low pH (e.g., lakes on the Canadian Shield) which typically are less abundant in native vegetation, fanwort may have a significant impact on these waters. Its winter die-back has been noted to release manganese suddenly which and impact nutrient cycling and water quality. The ecological impacts of fanwort may also be expected to diminish over time. In a recent study of the oldest population of fanwort in Kasshabog lake it was found that the diversity of sites where fanwort had been present for at least 14 years had recovered to pre-invasion levels without any management actions being taken.

Control Measures

Control for fanwort can be extremely difficult, unless the infestations are small. Since it reproduces via fragmentation, physical control activities (i.e., cutting or raking) can break up the plant unintentionally promoting the spread of plant parts. Generally, manual removal is recommended for small, recently established populations. The aim of management is generally to reduce the biomass of the plant, clear areas for navigation and prevent further spread of the plant. It is important to consider using containment measures where possible during control, such as floating booms. Fall is often the best time to undertake control because fanwort is still actively growing and the majority of native aquatic plants have died back. It is recommended to use sequestration curtains or other materials to enclose the infestation to prevent the movement of floating fragments in areas where water flow is minimal. Follow-up monitoring is recommended at least one time per growing season. Steps should be taken to reduce the risk of re-introduction such as public awareness campaigns, installing wash stations and monitoring the plant community.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (**page 6**) for details on how to prevent the spread of aquatic invasive plants.

This plant is not yet widely established in Ontario. If you think you've seen fanwort, particularly in a new location, take a picture, record the location and contact the Invading Species Hotline to report it. For more information and guidance call the **Invading Species Hotline at 1-800-563-7711** or visit www.invadingspecies.com or www.ontarioinvasiveplants.ca.

Manual Control

Hand Removal:

Hand pulling can be effective over a small number of acres where density is less than 500 plants per acre. It is not recommended to hand pull larger population as there is a risk of incomplete harvest or spread via fragmentation. Hand pulling can be done by standing or wading through shallow water and collecting and placing the plants into a plastic bag. Where possible, the person conducting the control should reduce movement through the water to avoid disturbing the plant. If possible, clear a small area completely before moving to a new area. Pull out plants very carefully and take the time to feel down to the root ball, making sure to remove the entire plant. Surround the area to be hand pulled with netting or a commercial curtain to contain the infestation.

Mechanical Control

Mechanical Harvesting:

Mechanical harvesting involves cutting the plant and collecting the plants using a net or hauling the cut biomass into a boat for disposal. Commercial harvester machines can also be used. This method can be used to control large infestations of fanwort. Since fanwort can spread via fragmentation, it is crucial to collect the plant fragments to prevent the spread of this plant. Monitor the post-harvest density. This method needs to be done continually in order to reduce the biomass of the plant because regrowth occurs quickly. Often, a harvested water body will only remain clear for several weeks. It is an expensive control method, but can be cost effective for priority situations, such as for areas that need to be cleared for navigation or safety reasons. Note: Mechanical harvesting can be very difficult in lakes which have numerous submerged stumps, such as Kasshabog Lake. Surround the area to be hand pulled with netting or a commercial curtain to contain the infestation. Harvesting can be more effective using suction apparatus to help prevent fragment distribution. This is also best for low to moderate densities of fanwort. This can include using a vacuum hose connection to a cutter bar on a scoop which cuts the plants and sucks them into an onboard bag.

Cultural Control

Benthic Barriers:

Benthic barriers are covers laid on the bottom sediment of a water body to block sunlight, preventing plants from photosynthesizing and suppressing their growth. The use of benthic barriers can be effective on small populations of fanwort to assist in local management and to reduce spread at a regional scale, including clearing areas for irrigation, recreation, or removal from small ponds where the entire bottom can be covered. It is best used in small areas (< 1 acre) that are relatively free of obstructions. A benthic barrier should be installed in the spring. The barrier must be strongly secured to the bottom using rocks, sandbags and concrete blocks. Effective control can be seen within 30 to 60 days, if the barrier is maintained to prevent sediment build-up on top of the barrier and gas build-up which could raise the barrier.

Biological Control

There are currently no biocontrol agents available for this invasive plant in Canada. Surveys of fanwort in its native range have found several natural enemies and the most promising biocontrol agent appears to be a stem eating weevil (*Hydrotimetes natans*).

Chemical Control

There are no aquatic herbicides registered in Canada that are specifically labeled for fanwort. The recently approved herbicide ProcellaCOR (PCPA Registration No. 24732) does work to control fanwort, however specific labelling has not yet been approved.

Control Techniques that are **NOT RECOMMENDED**:

- Cutting is not recommended for controlling fanwort. Cutting does not remove fragments from the water, leaving them to root in the sediment and grow a new plant. Cutting will contribute to the spread of the plant, impact water quality (i.e., lower dissolved oxygen and impact nutrient cycling) and can make the infestation worse.

Floating primrose-willow.

Photo courtesy of Peter Zika, iNaturalist, www.inaturalist.org/observations/98101625.

Floating Primrose-willow
(Ludwigia peploides)

Regulatory Status under Ontario's ISA: Restricted Species.

It is illegal to import, deposit, release, breed/grow, buy, sell, lease or trade this restricted invasive species in Ontario. It is also illegal to bring a restricted species into a provincial park or conservation reserve and to possess, transport, deposit or release them in these protected areas.

Introduction

Type of aquatic plant: An emergent, or floating aquatic plant.

Other names: It is also known as creeping water-primrose and is a member of the Onagraceae (Evening primrose-family).

Area of origin, introduction date and location: Native to South and Central America and southern USA. In North America, it was first noted in New York (USA) in 2003. This plant is adaptable to a wide range of environmental conditions which allow it to invade a variety of habitats.

Identification

Size and Stem:

Smooth or hairy (pubescent) stems that can grow between 10 - 300 cm. They can creep horizontally or grow vertically and are brown to reddish in colour.

Leaves:

Green, smooth polymorphic (varying shapes) that are less than 10 cm long, round (early growth) or oblong (older growth). They occur alternate along the stem.

Flowers:

Bright yellow, 5-petaled, 7 - 24 mm long and grow from the leaf axils. They bloom from July through October.

Fruits:

Five-angled capsule, 3 mm long that contains 40 - 50 seeds.

Roots:

Dimorphic (two forms). It has adventitious roots that form at the base of nodes and spread horizontally and are for oxygen uptake. Its other roots are attached downward into the substrate.

The stems are reddish to brown in color, and grow between 10 - 300 cm long.

Photo courtesy of J. Richard Abbott, iNaturalist, www.inaturalist.org/observations/46194269.

The leaves are green, oval-shaped and 10 cm long.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/95085491.

The flowers are bright yellow with 5 petals.

Photo courtesy of Cesar Ormazabal, iNaturalist, www.inaturalist.org/observations/180954051.

The fruits are a five-angled capsule.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/34500122.

Adventitious roots form at the based of nodes.

Photo courtesy of E. J. Richard Abbott, iNaturalist, www.inaturalist.org/observations/46194269.
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Floating Primrose-Willow and its Lookalikes

	Floating Primrose-Willow *(Ludwigia peploides)* INVASIVE	Marsh Primrose-Willow *(Ludwigia palustris)* INVASIVE	Water Primrose *(Ludwigia hexapetala)* INVASIVE
	 Photo courtesy of: Tom Pollard, iNaturalist, www.inaturalist.org/observations/85215252, licensed under CC-BY-NC.	 Photo courtesy of: TPat Deacon, iNaturalist, www.inaturalist.org/observations/144566896, licensed under CC-BY-NC.	 Photo Courtesy of: Pedro Alanis, iNaturalist, www.inaturalist.org/observations/11944252, licensed under CC-BY-NC.
Plant Type	• Emergent and floating	• Emergent and floating	• Emergent and floating
Stem	• Smooth or hairy • 10 - 300 cm long • Brown to reddish • Grow vertical or creep horizontally	• Smooth • 7 - 30 cm long • Reddish • Grow vertical or creep horizontally	• Hairy • Up to 92 cm long • Green to reddish • Grow vertical or creep horizontally
Leaves	• Leaves arranged alternate • **Round or oblong** • < 10 cm long	• Leaves arranged opposite • **Spoon-shaped with a blunt tip** • <10 cm long	• Leaves arranged alternate • **Spoon-shaped with a rounded tip** • 8 - 15 cm long
Flowers	• **5-petaled, vibrant yellow** • 7 - 24 mm long	• **No petals, 5 sepals, green** • 1.5 - 3.5 mm long	• **6-petaled, yellow** • Flowering stems more upright • 2.5 - 8 mm long
Fruit	• **Five-angled capsule** • 3 mm long	• **Four-angled capsule** • 2 - 5 mm long	• **Cylindrical capsule** • 3 - 4 mm long

Biology and Life Cycle

Floating primrose-willow is a perennial species. In the spring, leaves appear at the surface of the water. By early summer, this plant can grow 50 cm above the water's surface and flowering occurs in July to October. It can double its biomass in 15 to 20 days, allowing it to quickly overtake an area. This plant reproduces primarily through clonal expansion and stems can be spread via animals, humans and water currents. It can also produce a substantial number of seeds (10,000-14,000 seeds/m^2). They can float for up to two weeks. In the fall, this plant loses its stems, leaves and flowers and becomes dormant throughout the winter. Floating primrose-willow exhibits rapid growth, high nitrogen accumulation, and allocation of most biomass to aboveground plant parts which allow it to quickly take over an area.

Habitat

Floating primrose-willow can be found in a variety of environments such as wetlands, slow-flowing rivers, ponds, marshes and shorelines. It can grow in water up to 3 m deep and grow 80 cm above the water's surface. It can tolerate both wet and dry conditions.

Pathways of Spread

Floating water-primrose is a popular garden ornamental and infestations are often the result of intentional planting. Its subsequent spread can be attributed to water currents or attaching to nearby objects such as swimmers, or watercrafts.

Distribution

Floating primrose-willow is native to South and Central America and parts of the USA. There have been recent isolated sightings of this plant in Canada in the Cedar Creek-Frontal Lake Erie Area. It is also noted as invasive in areas in Africa, Asia, Europe and Australia. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Floating primrose-willow can alter dissolved oxygen, sulphide, phosphate and pH levels, leading to significant impacts on native plant species. It grows in very dense mats that prevent the growth of native plant species through shading. It also grows over the surface of other floating aquatic plants. Through displacing native plants, this can remove important food sources and shelter for native fish species and invertebrates. When these mats decompose, they significantly decrease dissolved oxygen, which can result in fish kills. Floating primrose-willow can also alter the physical and chemical properties of water through its allelopathic properties that influence water quality throughout the year and can make habitat unsuitable for native plants. Dense mats can sprawl along shorelines and drastically alter habitats by impeding the movement of water. Floating primrose-willow can also clog irrigation and drainage channels increasing the risk of flooding. Its dense growth can interfere with recreational activities such as hunting and hunting. Once established, it becomes extremely costly to control.

Control Measures

Floating primrose-willow is not established in Canada or Ontario. If you think you've seen floating primrose-willow or another invasive species in the wild, please take a picture, record the location and contact the toll free **Invading Species Hotline at 1-800-563-7711**, visit EDDMapS www.eddmaps.org, or search for the 'Invasive Species in Ontario' project on iNaturalist www.inaturalist.org to report a sighting. Early detection and rapid response are crucial to prevent the spread of this species. Prevention is the most effective way to reduce the spread of this invasive plant on a long-term scale. It is also important to never buy, plant or keep floating primrose-willow an aquarium or water garden. As

a restricted species, it is illegal to buy, sell, trade, possess or transport this invasion plant.

Small infestations and newly established infestations of floating primrose-willow can be managed through hand-pulling, digging or cutting. With any manual method, it is important to try and remove the entire root system, since floating primrose-willow can regenerate from small fragments. Manual removal is not recommended as a standalone method. Larger and more established populations can be managed through excavation, however, this is not recommended in environmentally sensitive areas. Small to medium infestations can be managed through tarping (terrestrial populations) or benthic barriers (aquatic populations). In other parts of its range, floating primrose-willow is managed primarily through chemical control. However, there are currently no herbicides registered to control this plant in Canada.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to prevent the spread of aquatic invasive plants.

Manual Control

Hand Pulling or Digging:

Small and newly established infestations (< 10 m^2) can be carefully removed through hand pulling or digging with a spade. Digging is typically more effective because floating primrose-willow has very thick and deep rhizomes. As this plant can regenerate from fragments, it is important to remove the entire roots system. It can be labour intensive and plants can re-establish from seeds or any remaining roots. This is not an effective standalone method because floating primrose-willow can spread from above and below ground fragments. Hand-pulling or digging is a good option in environmentally sensitive areas as it has the smallest risk of impact on non-target species.

Mechanical Control

Excavation:

Large and established infestations (> 100 m^2) can be controlled through excavation as plant roots will be buried in the sediment. A digger can be used to remove the plants and an addition 5 - 40 cm of sediment which can prevent regrowth through removing the rhizomes and seeds. Sites must be monitored for at least 5 years and any regrowth removed through manual control (i.e., hand pulling or digging). This method may require that all water be drained from the site which can drastically alter habitats and have negative impacts on non-target species.

Cultural Control

Tarping or Benthic Barries:

Covering an infestation with large sheets of thick, black plastic can kill plants underneath the tarp within 30 days. Tarping is most effective for infestations occurring in wet terrestrial environments. The tarp needs to be anchored and the edges need to be inspected throughout the growing season.

Benthic barriers are covers laid on the bottom sediment of a water body to block sunlight, preventing plants from photosynthesizing and suppressing their growth. The use of benthic barriers can be effective on small populations of water primrose-willow as it becomes very labour intensive with larger populations. It is important to use heavy PVC pond liners (18 oz or PVC vinyl) that are gas permeable to prevent them from rising to the surface. The benthic barrier should extend across the entire infestation including

along the margins (including channel banks). Barriers need to be secured to the sediment using bricks or rocks. This method can impact non-target species and should not be used in ecologically sensitive areas. Benthic barriers may not be effective in areas where the infestation also occurs in wet terrestrial environments.

Regulatory restrictions must also be considered. Benthic barriers are not permitted by Parks Canada for use in the Trent-Severn Waterway or the Rideau Canal. For projects on Provincial Crown land or shore lands, placement of these materials requires a work permit from MNR under the *Public Lands Act* as this control method does not fall under the provincial rules for removing invasive aquatic vegetation in Ontario without a work permit.

Biological Control

There are currently no biological control agents registered for use in North America.

Chemical Control

There are currently no approved herbicides for floating primrose-willow in Canada.

Floating primrose-willow.

Photo courtesy of Peter Zika, iNaturalist, www.inaturalist.org/observations/98101625.

Flowering rush infestation in Kenora, Ontario.

Flowering Rush
(Butomus umbellatus)

Regulatory Status under Ontario's ISA: Restricted Species.

It is illegal to import, deposit, release, breed/grow, buy, sell, lease or trade this restricted invasive species in Ontario. It is also illegal to bring a restricted species into a provincial park or conservation reserve and to possess, transport, deposit or release them in these protected areas.

Introduction

Type of aquatic plant: Emergent, or submergent aquatic plant.

Other names: Also known as greater flowering rush. It is the sole member of the family Butamaceae (Flowering Rush).

Area of origin, introduction date and location: It is native to Eurasia and Africa. The earliest records of it in Canada was in 1897 in the St. Lawrence River, Quebec.

Identification

Plant Type:

Emergent or submerged.

Size and Stem:

Emergent: 1 - 2 m in height, moderately tall; resembles large sedge or rush. Submerged: up to 3 m in height when fully submersed in water. Flowering stems are round, leaf stems triangular.

Leaves:

Triangular in cross-section, particularly at base, tend to flatten and twist spirally towards the leaf tip. Emerge directly from the rhizome, feel spongy and compressible, untoothed and parallel-veined. Leaves lax and floating when submerged; emergent leaves stiff, erect, tend to flatten and twist spirally towards the leaf tips.

Flowers:

Umbrella shaped clusters of 20 - 50 flowers. Each flower grows on a thin stalk, with three smaller outer sepals and three larger petals, both white to deep purple, sepals may be slightly green. Six carpels, nine stamens. Only plants in shallow water or dry sites (emergent plants) produce flowers, and only the fertile variety flowers consistently. Flowers June-September.

Fruits:

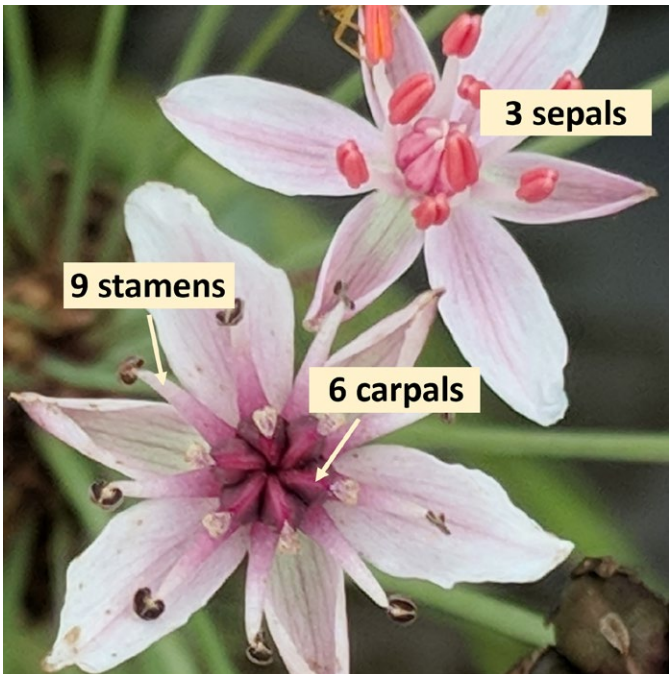
Dry crown-shaped seed capsule.

Roots:

Fleshy and rhizomatous. Extensive rhizome system. Bulbils may be present.

Flowering rush can grow as an emergent plant in shallow water. The leaves tend to flatten and twist spirally towards the leaf tips.

Photo courtesy of A. Connor, www.inaturalist.org/observations/48226714.



Each flower has three smaller outer sepals and three larger petals.

Photos courtesy of Mike Tidwell. www.inaturalist.org/observations/17424826.

Leaves are triangular in cross section.

Photo courtesy of Derek Stone, Riverwood Conservancy.

Flowering Rush and its Lookalikes

When flowering rush is in flower, the umbel-shaped cluster of pink – purple flowers in late summer is very distinct and unlike any other flowering marsh plant. However, when not in flower, flowering rush can be more difficult to identify as it resembles many other emergent or submergent shoreline species.

- **Tape or American eelgrass (*Vallisneria americana*)**: can resemble the submerged form of flowering rush but has a band of lacunae (air spaces) along the leaf midrib.

	Flowering rush Family *(Butomaceae)* INVASIVE	**Rush family** *(Juncaceae)* NATIVE	**Sedge family** *(Cyperaceae)* NATIVE	**Grass Family** *(Poaceae)* NATIVE
	 Photo courtesy of Wasyl Bakowsky.	 Photo courtesy of Robert H. Mohlenbrock, United States Department of Agriculture.	 Photo courtesy of Gary P. Fleming/DCR Natural Heritage.	 Photo courtesy of Gary P. Fleming/DCR Natural Heritage.
Plant Type	• Emergent/submerged	• Emergent	• Emergent	• Emergent
Stems	• Flowering stems are round in cross-section	• Round in cross-section • **Internodes are solid** • Nodes not jointed	• Usually three-sided in cross-section (except Scirpus spp.) • **Internodes are solid** • Nodes not jointed	• Round in cross-section • **Internodes hollow** • Nodes jointed, swollen

	Flowering rush Family *(Butomaceae)* INVASIVE	Rush family *(Juncaceae)* NATIVE	Sedge family *(Cyperaceae)* NATIVE	Grass Family *(Poaceae)* NATIVE
	 Photo courtesy of Wasyl Bakowsky.	 Photo courtesy of Robert H. Mohlenbrock, United States Department of Agriculture.	 Photo courtesy of Gary P. Fleming/DCR Natural Heritage.	 Photo courtesy of Gary P. Fleming/DCR Natural Heritage.
Leaves	• **Spiraling of emergent leaves** • Parallel-veined • **Triangular; spongy and compressible** • Arise basally from a stout, creeping rhizome	• Leaves do not spiral • Parallel-veined • Flat or round; not spongy or compressible • Three vertical rows • Arise basally • Sheath open in front, often auricled	• Leaves do not spiral • Parallel-veined • Flat or v-shaped; not spongy or compressible • Three vertical rows (in three columns when viewed from the side of the stem) • Sheath closed in front	• Leaves do not spiral • Parallel-veined • Flat; not spongy or compressible • Two vertical rows (on opposite sides of the stem) • Sheath open
Flowers	• Perfect; umbrella-shaped clusters of 20 - 50 white, pink to deep purple flowers on an erect, leafless flowering stalk • 3 petals and 3 sepals per flower • 9 stamens, 6 pistils per flower	• Tiny, round and green; female flowers 3 - 4 cm wide, male flowers 1 - 2 cm wide and bur-like • Flowers mid - late summer	• Small, up to 9 mm in diameter • Male or female plants (dioecious) **found in upper leaf axils.** Rise to or above the water surface at maturity • Female flowers raised to surface of water by 3 - 20 cm long, thread-like stalks	• Usually perfect • Each floret wrapped in 2 bracts/scales (called the lemma and palea)
Fruit	• Dry crown-shaped seed capsule	• Three-part capsule with many small, black seeds	• Achene; lens-shaped or 3-sided, may have bristles or hairs around the base. One seed (achene) for each flower	• Grain (caryopsis) • One seed for each flower

Biology and Life Cycle

Flowering rush is a perennial plant that develops an extensive root system once established. There are two reproductive types in North America: a fertile (diploid) type and a sterile (triploid) type. The fertile type has four methods of reproduction: seed, vegetative bulbils on the rhizomes or flowers, and by rhizome fragmentation. It flowers regularly throughout the summer, producing viable seed which ripens from August to September. The sterile type produces sterile flowers that rarely bloom, rarely produce any viable seed, and rarely produce vegetative bulbils, although they tend to produce more highly branched rhizomes than the diploid plants, allowing their rhizomes to fragment and break off more easily. Flowering rush will initiate growth in early spring typically in late February to mid-April, which is sooner than native aquatic vegetation. Leaf growth is rapid and peaks during mid-summer, then senesces in the fall. Flowering rush is very cold tolerant, but during the fall frost the leaves will die back and collapse to the ground instead of remaining upright like cattails.

Habitat

Flowering rush tends to prefer shallow areas with fluctuating water levels such as along shorelines, wetlands, lakes and irrigation canals, although it is also versatile and can be found in flowing water and in various substrate types (i.e., muddy or rocky). It can grow as an emergent plant along shorelines and riparian areas and as a submerged plant in depths up to 6 m in lakes and rivers. The fertile diploid types more commonly occur in shallow, emergent habitats and sterile triploid plants more commonly in deeper submerged habitats. It is intolerant of salt or brackish waters.

Pathways of Spread

Flowering rush can spread by being intentionally planted along waterways or in water gardens, or by excess plant material discarded in or near lakes, rivers, streams, ponds and wetlands. It can also be carried to new areas through flooding, or accidental movement of rhizome or bulbil fragments that break from the parent plant due to some disturbance, such as wave action caused by boating, or wildlife foraging.

Distribution

In Ontario, flowering rush occurs throughout the Great Lakes region, including Lake Erie, Lake St. Clair, Lake Ontario and the St. Lawrence River, Trent-Severn Waterway and the Rideau Canal. It is also found in regions as far north as Thunder Bay, and the Kenora district in northwestern Ontario. In North America, flowering rush is widely naturalized in wetlands, lakes, ditches, and slow-moving rivers in 21 U.S. states and 9 provinces. In Canada it has been found in British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island. In the United States, it is abundant in the Great Lakes states, and in the northern states closest to the Canadian border and is becoming an increasing problem in the far western U.S., including the Columbia River Basin. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Flowering rush has a moderate level of impact in Great Lake aquatic ecosystems. Although it can be found in sparse patches amongst native vegetation, it also has the potential to dominate wetland sites once established, forming dense monocultures that displace native vegetation and reduce biological diversity. At high densities, flowering rush may form a mat of plants which can separate and float on the surface and accumulate sediment, filling in shallow margins (littoral zones) of lakes or wetlands. Flowering rush can also increase water temperature, alter nutrient flows, and significantly alter fish habitat by covering open water normally used by native fish for

spawning. These dense stands provide ideal shelter for predatory fish such as northern pike (*Esox lucius*), which is a non-native and invasive species west of the continental divide in North America and which preys on native species like salmonids. Flowering rush can grow extensively, forming thick mats that clog irrigation ditches, canals, and impact power dam management, resulting in increased maintenance costs for removal. It also interferes with recreational activities such as boating, fishing, and swimming.

Control Measures

Control of flowering rush can be challenging. As this species mainly spreads vegetatively via rhizome fragments and bulbils on the rhizomes, the target of effective control must be to remove or destroy all rhizome and bulbil pieces. No single method is effective at removing all rhizome fragments. The most successful control programs have focused on taking an Early Detection and Rapid Response (EDRR) approach, identifying new populations through field surveys and then promptly removing individual plants to prevent further spread, and then continuing to control populations consistently over multiple seasons, often five years or more. An integrated approach, combining multiple methods (i.e., cutting and benthic barriers) is also more effective than doing one technique in isolation. Great care must be taken to remove all reproductive parts of the plant when implementing any physical control method. Dispose of removed plants properly, and thoroughly dry to prevent plants from sending new shoots. Although restoring a treated area with native vegetation could be beneficial, research indicates that flowering rush plants quickly reclaim sites that have been planted by native species.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (**page 6**) for details on how to report and prevent the spread of aquatic invasive plants.

Manual Control

Cutting Below the Water Line:

Repeat cutting during the growing season over multiple years can help limit spread as this will help strain the rhizome system. Cutting can help control spread and decrease abundance for small to medium-sized infestations but is time consuming and can be impractical. It is more effective in dryer, shallower areas, and very challenging in greater water depths (> 1.3 m). It is best to start cutting in early July, when plants are beginning to reach maturity, and repeated throughout the summer. Cut plants below the water line and remove all plant parts.

Cutting Seed Heads:

Cutting mature seed heads can help prevent spread in fertile diploid populations that produce viable seed. However, this method does not address the main method of spread (vegetative reproduction via spread of rhizomes and bulbils). Seed spread is not a critical method of spread for either fertile or sterile types. Sterile triploids which are more widely spread in Ontario rarely flower and produce sterile seed, while fertile diploid types show limited seeds in the seed bank, lack of seed production and failure of many seeds to germinate.

Hand Removal:

Hand digging can be used for controlling individual plants or small populations, to prevent further spread and establishment. This technique is best used in combination with an EDRR

program, monitoring for new populations, then using simple hand tools and buckets to remove the entire isolated plant. A pitchfork can gently lift the plant from the mud, then an individual can use their hands to get underneath the plant and lift it out without breaking the root system. The pitchfork should be plunged into the surrounding soil 20 - 30 cm from the plant at a 45° angle, going around the plant in a circle. Extreme care must be taken to remove all root fragments and bulbils, preventing them from escaping and spreading to new areas. Note that rhizome fragments as small as 1 cm have been observed to germinate. After removing the plant, search the area for any fragments and try to dislodge any bulbils that may float to the water's surface and dispose of properly. Control should be done when water levels are low enough to ensure that the entire plant is removed. Digging should not be done in high water due to the risk of spreading rhizome fragments and contributing to the growth of the population. This method is best applied each year during the growing season (summer) for several years. More frequent removals will give the most consistent control.

Biological Control

There are no biological controls currently available for flowering rush in Canada, however research by the Flowering Rush Biocontrol Consortium (FRBC) has identified several promising agents (Andreas *et al.* 2019):

- The rhizome and leaf-mining weevil (*Bagous nodulosus*)
- Stem and leaf-mining fly (*Phytoliriomyza ornata*)
- White smut fungal pathogen (*Doassansia niesslii*)

Chemical Control

There are no herbicides registered in Canada that are specifically labeled for flowering rush. Control of flowering rush using herbicides is difficult as it is easy for chemicals to miss or fall off the narrow, slightly twisted leaves of flowering rush.

See the Ontario Invasive Plant Council's Best Management Practices Guide on Flowering Rush **for more information this invasive plant and control methods.**

Control Techniques that are **NOT RECOMMENDED**:

- **Manual - Raking:** Can disturb shallow rhizomes and increase spread.
- **Mechanical - Mowing, rototilling or using machines like back hoes:** Can increase spread through rhizome fragmentation.
- **Benthic Barriers** - Difficult to install, expensive, laborious, requires routine monitoring and maintenance throughout growing season, non-selective.

Rhizomes have bulbils which can disperse and develop new plants.

Photo courtesy of Nick Proulx.

Hydrilla forms a dense mat of vegetation just below the water's surface.

Photo courtesy of David J. Moorhead.

Hydrilla
(Hydrilla verticillata)

Regulatory Status under Ontario's ISA: Prohibited Species.

It is illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade this prohibited invasive species.

Introduction

Type of aquatic plant: Submerged, aquatic plant. There are two forms of hydrilla; one where male and female flowers appear on separate plants (dioecious) and one where male and female flowers appear on the same plants (monoecious).

Other names: It is also known as water thyme, water weed, and Florida elodea, and is a member of the Hydrocharitaceae (frog-bit) family.

Area of origin, introduction date and location: Native to Asia. The dioecious (male and female flowers on the same plant) strain of hydrilla was introduced into Florida through the aquarium nursery trade in the 1950s and spread rapidly through intentional plantings. The monoecious (male and female flowers on different plants) strain was a separate introduction found decades later in Delaware in the 1980s.

Identification

Size and Stem:

Branched, 1 mm thick and up to 3 m long.

Leaves:

Whorled and attached directly to the stem (nodes). Each whorl can have between 3 - 8 leaves. The leaves measure 8 - 40 mm long, are bright green, lance-shaped with sharply toothed margins and have a prominent midrib.

Flowers:

Either male or female. Perianth (petals and sepals) are clear or translucent (sepals typically slightly reddish). They have 3 petals and 3 sepals. Male flowers are short-stalked (1.5 mm long), occur solitary (or occasionally in pairs) in the leaf axils and are somewhat spiny. Female flower petals and sepals are up to 4 mm long, and white or light green with red streaks. They extend on slender stalks up to 10 cm in length. Flowers appear during the summer and fall.

Fruits:

If produced are cylindrical (7 mm long and 1.5 mm wide) and contain 2 - 7 oblong seeds.

Roots:

The turions of hydrilla are formed from rhizomes are brownish with a smooth surface and those formed from erect stems are green with scales.

Hydrilla is a submerged, aquatic plant that can grow up to 3 m tall.

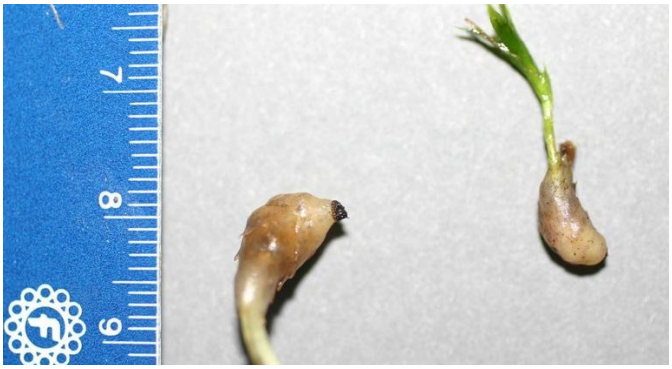
Photo courtesy of Ad Konings, iNaturalist, www.inaturalist.org/photos/308709379.

The leaves are whorled, bright green, lance-shaped with sharply toothed margins.

Photos courtesy of Eric M Powell, iNaturalist, www.inaturalist.org/observations/229000651.

The flowers are small, clear or translucent.

Photo courtesy of Alan R. Franck, iNaturalist, www.inaturalist.org/observations/197190536.



The turions are formed from rhizomes and are brownish with a smooth surface.

Photo courtesy of Leslie J. Mehrhoff, University of Connecticut, www.weedimages.org/browse/detail.cfm?imgnum=5480621.

Hydrilla and its Lookalikes

Hydrilla resembles the invasive Brazillian Waterweed (*Egeria densa*) (**page 17**).

	Hydrilla *(Hydrilla verticillata)* INVASIVE	Brazilian Waterweed *(Egeria densa)* INVASIVE	Canada Waterweed *(Elodea canadensis)* NATIVE	Nuttall's Waterweed *(Elodea nuttallii)* NATIVE
	 Photo courtesy of Robert Videki, Doronicum Kft, Bugwood.org.	 Photo courtesy of: Gail A. Baker, iNaturalist, www.inaturalist.org/observations/86591697, licensed under CC-BY-NC.	 Photo courtesy of Christian Fischer.	 Photo courtesy of Christian Fischer.
Plant Type	• Submerged	• Submerged	• Submerged	• Submerged
Stem	• Erect and rooted • Emerges from rhizomes and stolons • Up to 7.6 m long	• Erect, branched or unbranched • Up to 2 m long	• Slender, many branches formed along stem • Up to 2 m long. Many branches formed along stem	• Slender, many branches formed along stem • Up to 1 m long. Many branches formed along stem
Leaves	• **3 - 8 in a whorl, attached to stem without petioles** • Internode as long as leaves, up to 50 mm long • Green to yellow to brown in colour • **Margins with prominent, sharp teeth; sometimes prickles on midvein of lower leaf surface**	• **Lowest leaves opposite or in whorls of 3, smaller in size than middle and upper leaves** • **Middle and upper leaves in whorls of 4 - 6** • Bright green • **Leaf margins minutely toothed**	• Attached directly to the stem in whorls, with 3 leaves per whorl • **Leaves become densely crowded toward the top of plant** • **Lance-shaped on male plants and oval on female plants** • Bright green when young • **Leaf margins flat**	• Attached directly to the stem in whorls, with 3 leaves per whorl • **Lance shaped on male plants, oval on female plants, sharply pointed at tip** • Pale green • **Leaf margins folded**

	Hydrilla *(Hydrilla verticillata)* INVASIVE	Brazilian Waterweed *(Egeria densa)* INVASIVE	Canada Waterweed *(Elodea canadensis)* NATIVE	Nuttall's Waterweed *(Elodea nuttallii)* NATIVE
	 Photo courtesy of Robert Videki, Doronicum Kft, Bugwood.org.	 Photo courtesy of: Gail A. Baker, iNaturalist, www.inaturalist.org/observations/86591697, licensed under CC-BY-NC.	 Photo courtesy of Christian Fischer.	 Photo courtesy of Christian Fischer.
Flowers	• Small, male and female flowers on separate plants (dioecious) or same plant (monoecious) • **Male flowers short stalked, solitary or in pairs in leaf axils, whitish to reddish in colour,** petals and sepals 2 - 3 mm long • **Female flowers white or light green with red streaks,** petals and sepals up to 4 mm long, extend to water surface on slender stalk 10 cm in length • Flowers during summer and fall	• **Flowers do not occur in North America**	• Small, up to 9 mm in diameter • Male or female plants (dioecious) **found in upper leaf axils.** Rise to or above the water surface at maturity • Female flowers raised to surface of water by 3 - 20 cm long, thread-like stalks	• **Small, white with 3 petals at tips of long stalks** • Rise to or above the water surface at maturity
Turions	• **Those formed from rhizomes are brownish with a smooth surface** • **Those formed in leaf axil are green with scales**	• **Not present**	• **Not present**	• **Not present**

Biology and Life Cycle

Hydrilla can reproduce from plant fragments, by vegetative means through tubers and turions (reproductive structures that help the plant over-winter) and by seed. However, seed production is thought to be low compared to vegetative reproduction. Monoecious hydrilla behaves as herbaceous perennial where plant stands and fragments do not overwinter, while dioecious hydrilla overwinters in a vegetative stage and produces fewer tubers. It is important to note that the monoecious form of hydrilla (both male and female flowers on the same plant) puts more energy into tuber and turion production than the dioecious form, thus resulting in greater spread from this plant. The turions of monoecious hydrilla sprout at a much higher rate in cooler temperatures compared to the dioecious form. The tubers and turions of both forms can survive drought condition, ice cover and regurgitation by waterfowl.

In the spring, hydrilla sprouts from over-wintering tubers and turions, typically once water temperatures are between 11 - 13 °C. Optimal growth occurs between 25 - 36 °C and accelerated growth of hydrilla stars when water temperatures exceed 21 °C. It can grow almost 2 cm per day. Flowers, tubers and turions are produced throughout the growing season. In the fall, as the plant begins to die back, the tubers and turions drop to the sediment. The plants die back completely to the sediments by early winter. Tubers and turions over-winter and sprout new plants the following spring. Tubers can remain dormant for several years and research has indicated that one tuber can produce over 6,000 new tubers in one square metre which can remain viable for up to 4 years. Hydrilla can also propagate readily from broken stem or root fragments.

Habitat

Hydrilla is found in lakes, rivers, ponds, streams, and wet ditches. It thrives in disturbed areas and can tolerate poor water quality. It prefers warmer waters between 25 - 36 °C. It can withstand low light (< 1%) and carbon dioxide conditions. It can withstand low light conditions, allowing it to grow in water up to 7 - 10 m deep, but optimal growth occurs at depths of 90 cm.

Pathways of Spread

Hydrilla can be spread naturally via plant fragments, tubers and turions that can float to new locations. It was also intentionally introduced as an ornamental and aquarium plant in the USA. While hydrilla is a prohibited species under the *Invasive Species Act* (ISA), it is possible that it may accidentally spread through the illegal dumping of aquarium contents into waterways. It can also spread between waterbodies from plant fragments and turions that attach to boats, boat trailers, and other equipment.

Distribution

Hydrilla has recently been reported in Canada in Ontario at Hillman Marsh Conservation area in Leamington Ontario. In the United States, it is found in approximately 30 states. It was discovered in the Cayuga Inlet in the Finger Lakes and Niagara River region of New York State in 2011. Its dioecious form is mainly found in the southern United States, whereas the monoecious form is found north of South Carolina. The monoecious form presents a greater risk to Ontario, because of its ability to grow and reproduce in colder temperatures. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Hydrilla is considered to be one of the world's worst invasive aquatic plants. It can form very dense mats that have the potential to completely block a waterbody. This tends to create very stagnant waters that have a bad odour and many increase mosquito populations. Its ability to grow under low light conditions allows the plant to colonize deep water, where native vegetation cannot grow. This allows it to form dense mats in surface waters that can block out light for other plants, leading to a competitive advantage and a reduction in plant diversity. Dense stands alter water quality through increasing pH and temperature. When hydrilla begins to decompose, it consumes dissolved oxygen, limiting the availability for fish. A type of cyanobacteria (*Aetokthonos hydrillicola*) is found on hydrilla leaves and when consumed by invasive snails, create a toxin that causes avian vacuolar myelinopathy (AVM) which is a fatal disease for many bird species. Research has shown that hydrilla has allelopathic effects on phytoplankton, leading to reduction in biomass. Hydrilla impacts recreational uses of waterways, such as angling, boating, and swimming. It can also increase maintenance costs for irrigation and hydroelectric plants. Tourism can also be impacted by hydrilla as it can create a bad odour which can be unpleasant to tourists. Once established it forms a dense mat in a waterbody, it becomes extremely costly to control, costing millions of dollars annually.

Despite its negative impacts, hydrilla has been used to treat waste waters and remove heavy metals.

Control Measures

This plant is known to occur in only one location in Ontario (and Canada). If you think you've seen hydrilla or another aquatic or wetland invasive plant in the wild, take a picture, record the location and contact either the toll-free **Invading Species Hotline at 1-800-563-7711**, visit EDDMapS www.eddmaps.org, or search for the 'Invasive Species in Ontario' project on iNaturalist www.inaturalist.org. to report a sighting.

Early detection and rapid response is key to prevent the establishment of hydrilla. Prevention is the most effective way to reduce the spread of this invasive plant on a long-term scale. Management options must be considered carefully to avoid spreading the plant which can reproduce vegetatively. Hydrilla can be challenging to manage because most control efforts risk fragmenting the plant which can lead to it regeneration. Options like mechanical harvesting can make the situation worse. Manual removal must also take into consideration tubers and turions in the sediment as these can lead to regrowth. Small areas can be managed with excavation or dredging as this removes tubers in the sediment, preventing regrowth. Water level control may also be effective in areas where water levels can be manipulated such as landlocked ponds. However, drawdowns need to take into consideration conditions that may promote growth, timing of herbicide application and where the outflow discharge goes to prevent spread. Longevity of the turions/tubers also needs to be considered. This method should also be done in conjunction with the application of an herbicide. Chemical control of hydrilla is typically the only effective method for larger populations. Herbicides with the active ingredient florpyrauxigen are effective for controlling hydrilla, including a newer product, ProcellaCOR FX (PCPA Registration No. 34732).

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to report and prevent the spread of aquatic invasive plants.

Mechanical Control

Excavation or Dredging:

Small areas (< 2 hectares) can be managed via excavation or dredging. At least 45 cm depth of sediment should be removed to eradicate the infestation. Removing this amount of sediment, reduces the "tuber bank". Ensure to properly dispose of excavated material in order to prevent accidental introductions or further spread.

Cultural Control

Water-level Control:

In areas where the water levels can be manipulated (i.e, landlocked ponds, irrigation channels, stormwater ponds and reservoirs), water drawdowns in winter (to control existing hydrilla population) and mid-summer can be an effective control method to reduce the viability of tubers through desiccation. This only works temporarily since tubers can remain dormant. This is best used in conjunction with the application of sediment-applied herbicide.

Chemical Control

Large infestations of hydrilla can be controlled with herbicides. Currently there are two registered herbicides to control hydrilla in Canada whose active ingredient is florpyrauxifen. This includes a newer, more selective herbicide called ProcellaCOR FX (PCPA Registration No. 34732). See the product label for details on timing of application, intervals of treatment, and concentrations. Note that only those with the appropriate aquatic pesticide exterminator license are permitted to use this product, and a permit may be required.

Before using any pesticide, ensure you have the most current label. Pesticide labels can be accessed using the PMRA's label search tool, which can be found by searching "PMRA label search" in any major search engine. Always read and follow all directions on the label. The label is a legal document that must be followed exactly, including any applicable buffer zones. Using a pesticide to treat a species not listed on the label, or in a manner other than specified on the label violates the *Pest Control Products Act* and may incur penalties.

Biological Control

There are currently no biological control options for hydrilla in Canada. In the USA, several host specific insects have been released including flies (*Hydrellia pakistanae* and *Hydrellia balciunasi*), a moth (*Paraponyx dimunutalis*) and a weevil (*Bagous affinis*).

Not Recommended:

- While larger infestation can be removed through mechanical harvesting, this is not recommended. Since hydrilla can regenerate from small fragments, mechanical harvesting may stimulate growth and spread thousands of these plant pieces which can start new population.

Oxygen weed infestation in Kapitia Reservoir, Northern Ward, West Coast, New Zealand.

Oxygen Weed
(Lagarosiphon major)

Regulatory Status under Ontario's ISA: Prohibited.

It is illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade this prohibited invasive species in Ontario.

Introduction

Type of aquatic plant: Submerged, aquatic plant

Other names: It is a member of the Hydrocharitaceae (Frog's-bit) family, and is also known as African elodea, Lagarosiphon, curly water weed, and African waterweed. It is often mislabelled as *Elodea crispa* in the aquarium trade.

Area of origin, introduction date and location: Native to Southern Africa, including Zimbabwe, South Africa, Zambia, and Botswana. It has spread invasively to Europe, the UK, and Australia. It has not yet been detected in North America.

Identification

Plant Type:

Submerged, aquatic plant.

Size and Stem:

The brittle, sparsely branched stem can grow up to 6 m long, is 3 - 5 mm in diameter and curves like a 'J' towards the base.

Leaves:

Leaves are dark green and alternately spiralled around the stem, often crowded towards the stem tip. Leaves are minutely toothed, 5 - 20 mm long, 2 - 3 mm wide, with tapered tips that curve down towards the stem.

Flowers:

Female flowers are small, 6 petals, petals are transparent, white, pink or purple, growing on long, clear stalks, on the surface of the water. Flowers sprout from summer to early fall.

Fruits:

The fruit is a beaked capsule, containing approximately nine seeds, each seed being approximately 3 mm long.

Roots:

Adventitious roots and rhizomes attach the plant to the substrate.

Flowers are small, 6-petalled, white, pink or purple, grow on long clear stalks on the surface of the water.

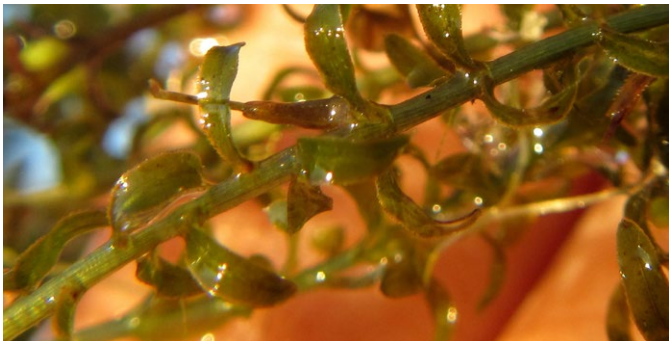
Photo courtesy of Ricky Taylor, iNaturalist, www.inaturalist.org/observations/142054119.

Stems can grow up to 6 m long.

Photo courtesy of Rohan Wells, National Institute of Water and Atmospheric Research, Bugwood.org, CC-by-NC.

Leaves are often crowded towards the stem tip.

Photo courtesy of Victoria Zelenkova, iNaturalist, www.inaturalist.org/observations/191174279.



Leaves are alternately spiraled around the stem.

Photo courtesy of Ricky Taylor, iNaturalist, www.inaturalist.org/observations/11198035.

Oxygen Weed and Its Lookalikes

Oxygen weed can resemble other species in the family Hydrocharitaceae, including Brazilian waterweed (*Egeria densa*), Canada waterweed (*Elodea canadensis*), and hydrilla (*Hydrilla verticillata*). In comparison, the leaves of oxygen weed are alternatively spiralled, compared to the other three species, which are arranged circularly (in whorls) around the stems. The presence of recurved leaves and a downward curving stem towards the apex also distinguishes it from the other three species. The female flowers of oxygen weed have 6 petals, are small, purple or pink, and grow on long clear stalks on the surface of the water. Hydrilla also has similar small flowers on long stalks like oxygen weed but flowers are greenish in colour. The flowers of Brazilian waterweed are larger (9 - 12 mm) than oxygen weed, are white with three petals. Canada waterweed has white flowers with three petals. For more details on distinguishing lookalikes, see the lookalikes table in the Brazilian waterweed section.

Biology and Life Cycle

Oxygen weed is a dioecious, perennial aquatic plant that will root in the substrate through adventitious roots and rhizomes. Outside its native range, only plants with female flowers have been identified, while male flowers, fruits, and seeds have not been recorded. Oxygen weed is dormant in the winter, emerging in the spring from rhizomes and shoots. The female flowers bloom from summer to early fall, and growth decreases as day length and light intensity decrease during the fall. Its preferred temperature is between 20 - 23 °C, with a maximum temperature of 25 °C and under 10 °C plants will become dormant. It is known to over-winter in southern areas of the UK and it has been found to survive temperatures as low as 1 - 3 °C, therefore could survive mild Canadian winters.

Habitat

Oxygen weed prefers slow-moving water or areas sheltered from elements such as wind and wave action. It is found in lakes, wetlands, dams, reservoirs, and slow-moving rivers with silty or sandy bottoms. It can grow in a range of nutrient levels including areas that are nutrient poor, however it prefers areas of high light intensity. In eutrophic lakes with decreased water quality and/or opaque or highly turbid waters, abundance declines.

Pathways of Spread

Historically, oxygen weed has spread to new areas through trade as a popular aquarium and water garden plant, particularly over the internet and through mail order. While it is now illegal to import, possess, transport, deposit, release, propagate, buy, sell or trade oxygen weed, these plants may still be available illegally in Ontario. It may be accidentally introduced into waterbodies by flooding of ornamental ponds, or when people dispose of aquarium contents into waterways. It might also be a hitchhiker plant through mislabelling in water garden catalogs. Oxygen weed can then spread to new locations when female plant fragments are broken through water currents, or by the movement of boats, trailers, nets, and other recreational equipment. Plant fragments as small as 1 cm in length have the potential to embed in the substrate and form a new plant, however, oxygen weed tends to have a lower fragmentation rate and dispersal potential compared to Brazilian waterweed.

Distribution

Oxygen weed is not currently established in North America. It is a prohibited species in Ontario, a regulated species in 10 US states, and listed as a noxious weed or prohibited in many parts of the world including the European Union. It was introduced to New Zealand in the 1950s, where it continues to invade many freshwater lakes in the region. The first European record was in Britain

in 1944, and it has since spread to several other European countries, including Germany, Ireland, Belgium and the Netherlands.

Impacts

Oxygen weed can outcompete both native and non-native submerged vegetation by growing thick, dense mats quickly, which can cover large areas through vegetative propagation. These dense mats can be 2 - 3 meters in depth, and its "J" shaped stem can reach up to 6.5 meters long towards the water's surface. In New Zealand, oxygen weed was found to produce roots faster and grow faster, both in length and biomass, than native milfoils (*Myriophyllum* spp.) and pondweeds (*Potamogeton* spp.), giving it a competitive advantage. It outcompetes other species for light and reduces water quality by altering its chemical composition. During photosynthesis, it creates an envelope of raised pH (up to 10.4), raises dissolved oxygen concentrations, and depletes dissolved carbon dioxide. In stagnant water conditions, this can inhibit the growth of neighbouring plants. While the name 'oxygen weed' refers to the species ability to oxygenate the water, the dense mats in its introduced range decrease oxygen levels by limiting water circulation and increasing decomposition. Decomposing mats reduce dissolved oxygen levels in the water, contributing to fish kills and making the water inhospitable to invertebrates and other aquatic plants. In addition, dense populations can interfere with recreational activities, such as boating, fishing, and swimming, interfere with hydroelectric generation and drainage, and increase flooding impacts. Despite its negative impacts, it can provide some habitat for aquatic fauna, its leaf surface supports periphyton, and plant stands can increase sedimentation, which could be beneficial in some areas.

For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist at www.inaturalist.org.

Control Measures

There are no populations of oxygen weed in North America. As a prohibited species under the *Invasive Species Act* (ISA), prevention and early detection are prioritized. Oxygen weed is challenging to control due to its ability to spread by plant fragments and underwater roots and rhizomes. Make sure to monitor boat launches frequently as these are often the initial sites of invasion for many aquatic invasive species. Refer to section Prevent the Spread (p**age 6)** for details on how to prevent the spread of aquatic invasive plants.

This plant is not yet widely established in Ontario. If you think you've seen oxygen weed, particularly in a new location, take a picture, record the location and contact the Invading Species Hotline to report it. For more information and guidance call the **Invading Species Hotline at 1-800-563-7711** or visit www.invadingspecies.com or www.ontarioinvasiveplants.ca.

Parrotfeather infestation.

Photo courtesy of Graves Lovell, Alabama Department of Conservation and Natural Resources, Bugwood.org.

Parrotfeather
(Myriophyllum aquaticum)

Regulatory Status under Ontario's ISA: Prohibited Species.

It is illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade this prohibited invasive species in Ontario.

Introduction

Type of aquatic plant: Submerged, aquatic plant.

Other names: It is also known as parrot feather, water-milfoil, Brazilian water-milfoil and water-feather and is a member of the Haloragaceae (Water-milfoil) family.

Area of origin, introduction date and location: Native to South America, and was first introduced to North America via the aquarium trade, most likely in the late 1800s, being recorded in a Washington in 1890. At the time this document was written, there are no known extant populations of this plant in the wild Ontario. While a small population had been found in an isolated pond in Midhurst, it was successfully eradicated in 2006.

Identification

Size and Stem:

Grows 2 - 5 m long. It has submerged shoots that widely branch from the nodes (where leaves attach). It also has emergent leaves which can grow up to 30 cm above the water surface.

Leaves:

Heterophyllous (forms that occur above water (emergent) and below water (submerged)). They are whorled and divided into thread-like segments (filiform). The emergent leaves are feather-like, lime-green, "waxy" and are arranged in whorls of 4 - 6 leaves (2.5 - 5 cm long, with 10 - 18 leaflet pairs). The submerged leaves are limp, brownish to reddish in colour, often appear to be decaying and are arranged in whorls of 3 - 6 leaves (1.5 cm - 3.5 cm long).

Flowers:

Small (approximately 1.6 mm long), white and occur on whorled terminal spike at the tips of emergent stems. They typically appear in the spring or summer.

Fruits:

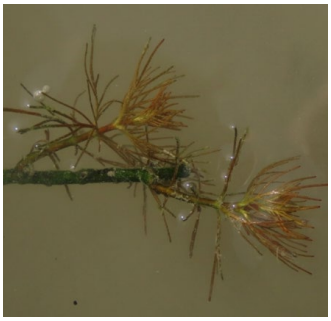
All plants in North America are female and do not produce fruits.

Roots:

The rhizomes can either root in the sediment (if the water is shallow) or remain unburied and float just under the water's surface.

Parrotfeather is a submerged, aquatic plant grows 2 - 5 m long. It also has emergent leaves.

Photo courtesy of A. iNaturalist, www.inaturalist.org/observations/168683486.



The emergent leaves (left) are feather-like, lime-green and waxy and the submerged leaves (right) are limp, brownish to reddish.

Photos courtesy of Ulises Infante, iNaturalist, www.inaturalist.org/photos/97979212 and iNaturalist, www.inaturalist.org/observations/172532367.

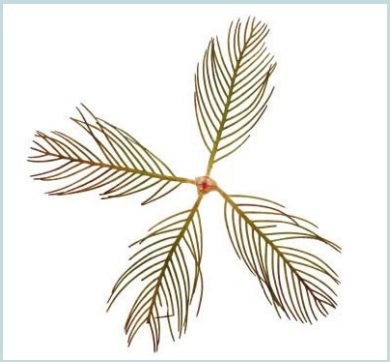
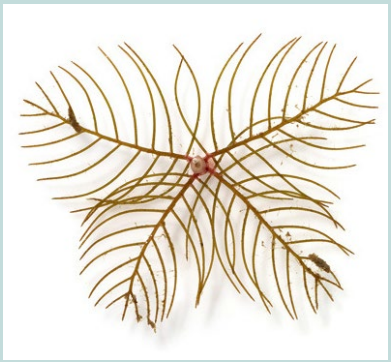
The flowers are white and occur on a whorled, terminal spike.

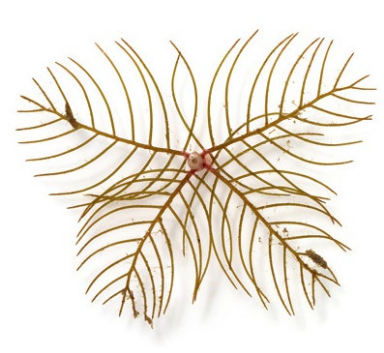
Photo courtesy of Jacqui Geux, iNaturalist, www.inaturalist.org/observations/17491040.

The rhizomes either root in the sediment or remain unburied.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/207141147, licensed under CC-BY-NC.

Parrotfeather and its Lookalikes

	Parrotfeather (*Myriophyllum aquaticum*) INVASIVE	**Eurasian Water-Milfoil** (*Myriophyllum spicatum*) INVASIVE	**Northern Water-Milfoil** (*Myriophyllum sibiricum*) NATIVE
	 Photo courtesy of Maryland Department of Natural Resources.	 Photo courtesy of Fero Bednar (www.wnp.sk), iNaturalist, www.inaturalist.org/observations/133132060.	 Photo courtesy of Fero Bednar (www.wnp.sk), iNaturalist, www.inaturalist.org/observations/133132060.
Plant Type	• Submerged/Emergent	• Submerged	• Submerged
Stalks	• 2 - 5 m long • **Submerged leaves branch repeatedly** • **Emergent stems are green and stiff**	• 0.5 - 7 m long • Leafy shoot, branching repeatedly • **Stem tips usually reddish** • **Stem diameter below inflorescence greater than lower stem.** • Stems readily collapse when removed from water	• 0.5 - 7 m long • Leafy shoot, branching repeatedly • Stems are typically whitish • **Stem tips usually green, can be red in some spots** • **Stem diameter below inflorescence is the same as lower stem**

	Parrotfeather (*Myriophyllum aquaticum*) INVASIVE	Eurasian Water-Milfoil (*Myriophyllum spicatum*) INVASIVE	Northern Water-Milfoil (*Myriophyllum sibiricum*) NATIVE
	 Photo courtesy of Maryland Department of Natural Resources.	 Photo courtesy of Fero Bednar (www.wnp.sk), iNaturalist, www.inaturalist.org/observations/133132060.	 Photo courtesy of Fero Bednar (www.wnp.sk), iNaturalist, www.inaturalist.org/observations/133132060.
Leaves	• Arranged in whorls of 4 - 6 and feather-like • Pinnately divided with 10 - 18 pairs of leaf segments on each leaf • **Whorls openly spaced toward the base and closely arranged toward the tip of the stem** • **Emergent leaves robust, vibrant green, covered with waxy coating** • **Submerged leaves limp and brown**	• Arranged in whorls of 3 - 6 (typically 4) and feather-like • Pinnately divided with 14 - 21 leaflet pairs on each leaf • **Whorls are spaced 1 - 3 cm apart** • **Tops of leaves often flat-topped**	• Arranged in whorls of 4 - 6 and feather-like • Pinnately divided with 11, or less than 11, pairs of leaf segments on each leaf • **Whorls are spaced up to 1 cm apart** • **Tops of leaves rounded**
Flowers	• Emergent, on a terminal spike above water 5 - 10 cm long • **Flower is 1.6 mm long** • Dioecious (male and female flowers on different plants). **All plants in North America are assumed to be female** • White • Flowers between May and August	• Emergent, on terminal spike above water, 5 - 20 cm long • Flower is 4 - 6 mm long • Monoecious (male and female flowers on the same plant). Upper flowers male and lower flowers female • Pink or white (frequently white), arranged in whorls; **flowers larger than bracts; bracts have smooth margins** • Flowers between late July and early August	• Emergent, on terminal spike above water, 4 - 15 cm long • Flower is 3 mm long • Monoecious (male and female flowers on the same plant). Upper flowers male and lower flowers female • Pink in colour, arranged in whorls; flowers small; **bracts equal to or slightly longer than female flowers and have serrated margins** • Flowers between late July and early August

Biology and Life Cycle

Parrotfeather is a perennial that reproduces through vegetative means via rhizomes and plant fragmentation (a process where part of the plant is removed from the plant by natural or mechanical means and produces a new plant). Plant fragments as small as 4 mm can establish a new population. Parrotfeather is a dioecious plant (female and male flower occur on different plants). In its native range, it produces both male and female flowers on separate plants, however in the United States and Canada, only female plants are known to occur. Thus, populations do not produce seeds. This plant shows an annual growth pattern whereby it has rapid shoot growth in the spring from overwintering rhizomes. In the summer, it exhibits emergent growth. Plants typically flower in the spring. Submerged leaves exhibit senescence as the growing season progresses and plants die back to their rhizomes. This plant can survive in water of poor quality as it can tolerate high levels of ammonia and other toxins. While it can tolerate fluctuating water levels, its ability to photosynthesize via its submerged leaves decreases with increasing water depth.

Habitat

Parrotfeather typically grows rooted in nutrient-rich and slow-moving waters such as ponds, lakes, ditches and wetlands. It grows best in shallow waters but also occurs as a floating plant in deep high-nutrient waters up to 4.8 metres. This plant is typically found in habitat where light can penetrate the bottom to allow submersed leaves to conduct photosynthesis, alkaline conditions (pH between 6 - 8) and warmer waters (between 16 - 23 °C). It can survive during seasonal drought when it may be "stranded" on riverbanks or lake shores with no water. It can also typically survive winters in its submersed form.

Pathways of Spread

The main pathway of spread for parrot feather is through the aquatic plant trade. While it is illegal in Ontario to buy or plant this species as per the *Invasive Species Act* (ISA), intentional planting and the improper disposal of aquarium contents, are considered the main source of wild populations. Once in a body of water, it can spread unintentionally via flooding events, on the feet of waterfowl or attach to boats, boat trailers, or other equipment such as fishing gear. Plant fragments can float long distances downstream.

Distribution

Parrotfeather is native to the Amazon River in South America and was introduced to North America in 1890 in Washington. It now occurs all states with the exception of Nevada, Wyoming, Colorado, Montana, North Dakota, South Dakota, Nebraska and Iowa. In Ontario, a very small population of parrotfeather was found in a public pond in the Midhurst area. This population was eradicated by filling in the pond in 2006. It was also found in a decorative water feature on a property near Mallorytown, ON in 2018. This water feature was removed and the plants secured to prevent the spread to adjacent wetlands. In Canada, it is also present in British Columbia in the City of Richmond (in Pitt Meadows), Burnaby, Surrey and south Vancouver. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Dense infestations of parrotfeather can rapidly overtake small ponds and lakes and significantly alter physical and chemical properties. This includes impeding water flow, leading to increased flood possibility and lowering the oxygen content of water. It can shade out algae and pondweeds that provide a source of food for waterfowl. Invaded sites typically show lower plant

diversity. There is some evidence that this plant produces allelopathic chemicals that prevent the growth of nearby plants. Parrotfeather can also choke waterways, block drainage and irrigation channels, and can impede the movement of watercrafts. This can restrict recreational activities such as angling, swimming, and boating.

Despite its negative impacts, parrotfeather has shown great phytoremediation potential as it can accumulate heavy metals. For this reason, it has been considered a bioindicator of heavy metal concentrations in a waterbody.

Control Measures

There are currently no known self-sustaining established populations of parrotfeather in Ontario. If you think you've seen parrotfeather or another invasive species in the wild, please take a picture, record the location and contact the toll free **Invading Species Hotline at 1-800-563-7711**, visit EDDMapS www.eddmaps.org, or search for the 'Invasive Species in Ontario' project on iNaturalist www.inaturalist.org. to report a sighting.

Early detection and rapid response is key to prevent the establishment of parrotfeather. Prevention is the most effective way to reduce the spread of this invasive plant on a long-term scale. Management options must be considered carefully to avoid spreading the plant which can reproduce vegetatively. Large infestations can be controlled through excavation to remove plant roots, stems and contaminated sediment in an effort to prevent plants from regrowing. This is best done in March to expose the sediment to freezing temperatures. Benthic barriers can also be an effective control method, typically for smaller populations where the entire infestation, including plant on the shoreline can be covered. Finally, water drawdown can be effective in waterbodies where the water level can be controlled such as landlocked ponds or reservoirs. This method works by exposing plant roots to desiccation, preventing plants from growing. Control methods must be repeated over several years to eradicate this plant.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to report and prevent the spread of aquatic invasive plants.

Manual Control

Hand Pulling or Harvesting:

Repeated hand pulling (smaller infestations) or harvesting (larger infestations) can be an effective management strategy. However, caution must be taken to prevent the spread of the plant. An effective way to prevent the spread of this plant is to contain the infestation using netting or screens. For smaller infestation, a cloth screen (1/4" mesh) can be installed both upstream and downstream of the infestation. For larger infestations that occur in a larger watercourse, the infestation can be contained using a floating net with lead liners placed upstream and downstream. It is extremely important to remove any plant fragments to prevent the plant from regenerating. Hand pulling is most effective for smaller populations. Parrotfeather has been noted to be tolerant of mechanical disturbance and often, these methods can lead to new infestations as fragments can grow new plants.

Mechanical Control

Excavation or Dredging:

Large infestations of parrotfeather can be removed through excavation in areas where the water depth is less than 0.5 metres. An excavator

can remove plant parts and contaminated sediment. This is most effective if done in the early spring (March) when the overwintering mass of parrotfeather is visible. Follow-up treatment must be done in June or July when any missed plant parts can regenerate. At least 15 - 25 cm must be removed to prevent regrowth. Combining excavation with water drawdown is also effective.

Cultural Control

Benthic Barrier:

Benthic barriers are covers laid on the bottom sediment of a water body to block sunlight, preventing plants from photosynthesizing and suppressing their growth. The use of benthic barriers can be effective on small populations of parrotfeather. It is important to use heavy PVC pond liners (18 oz or PVC vinyl) that are gas permeable to prevent them from rising to the surface. The benthic barrier should extend across the entire infestation including along the margins (including channel banks). If multiple liners are required to cover the entire infestation, it is important that they overlap by at least 15 cm and be connected using 50 cm spikes with washers to have no open seams where the rhizomes can penetrate. Barriers need to be secured to the sediment using bricks or rocks. This method can impact non-target species and should not be used in ecologically sensitive areas.

Regulatory restrictions must also be considered. Benthic barriers are not permitted by Parks Canada for use in the Trent-Severn Waterway or the Rideau Canal. For projects on Provincial Crown land or shore lands, placement of these materials requires a work permit from MNR under the *Public Lands Act* as this control method does not fall under the provincial rules for removing invasive aquatic vegetation in Ontario without a work permit.

Water Drawdown:

In areas where the water level can be controlled (i.e., landlocked ponds or reservoirs) water drawdown can be effective as it exposes the sediment and plant roots to desiccation. If the sediments remain dry, a water drawdown of more than 3 consecutive months can completely eradicate parrotfeather.

Biological Control

There are currently no biological control agents available to control parrotfeather in Canada. However, leafing feed insects (*Lysathia* spp. and *Listronotus marginicollis*) have been found to reduce emergent vegetation and fungal pathogen, *Pithium carolinianum*, causes root and stem root.

Chemical Control

Due to potential risks to aquatic species and poor absorption, *chemical control is not recommended for parrotfeather*. There is currently one registered herbicide to control parrotfeather whose active ingredient is florpyrauxifen. See the product label for details on timing of application, intervals of treatment, and concentrations. Note that only those with the appropriate aquatic pesticide exterminator license are permitted to use this product, and a permit may be required.

Regulatory restrictions must also be considered. Benthic barriers are not permitted by Parks Canada for use in the Trent-Severn Waterway or the Rideau Canal. For projects on Provincial Crown land or shore lands, placement of these materials requires a work permit from MNR under the *Public Lands Act* as this control method does not fall under the provincial rules for removing invasive aquatic vegetation in Ontario without a work permit.

Phragmites can reach up to 5 m in height.

Photo courtesy of Matt Smith.

Invasive *Phragmites*
(European Common Reed) *(Phragmites australis* subsp. *australis)*

Regulatory Status under Ontario's ISA: Restricted Species.

It is illegal to import, deposit, release, breed/grow, buy, sell, lease or trade this restricted invasive species in Ontario. It is also illegal to bring a restricted species into a provincial park or conservation reserve and to possess, transport, deposit or release them in these protected areas.

Introduction

Type of aquatic plant: Emergent, wetland plant (grass).

Other names: It is a member of the Poaceae (Grass) family and is also known as European common reed, common reed, common reed grass, or giant reed.

Area of origin, introduction date and location: It is native to Eurasia and was likely introduced in North America in the 1800s along the Atlantic coast.

Identification

Size and Stem:

Tall grass; up to 5 m. Stem is hollow, green near the tip, lower stems turn dull tan or beige, rough texture, 0.5 - 1.5 cm in diameter. Underneath leaf sheaths (part of leaf that surrounds the stem), the stem is a pale-brown colour in the summer and fall months.

Leaves:

Blue-green, alternate, flat, gradually taper to a point, often held at a 45° angle from the stem. Ligules are less than ≤ 0.15 mm wide excluding the hairy fringe, somewhat translucent, fraying into short, matted hairs, with longer hairs at the collar (The area on the outer side of the leaf where the blade and the sheath join).

Flowers:

Seedheads produce 3 - 10 flowers and long, soft, white hairs that give it a feathery appearance.

Fruits:

Easily distinguished later in growing season when large, dense seed heads form (seeds heads are called a panicle). Initially purplish brown, become fluffier and turn white to tan colour.

Roots:

Underground rhizomes and above ground stolons.

Immature seed head are a purple-brown colour.

Photo courtesy of Dan Engel.

Mature seed heads become fluffier in appearance.

Photo courtesy of Lauren Bell.

Dead stalks in the winter are a tan to grey colour.

Photo courtesy of Tom Erler, iNaturalist, www.inaturalist.org/observations/107071766.

Leaves are blue-green, alternate, flat, gradually tapering to a point and often held at a 45-degree angle from the stem.

Photo courtesy of Owen Clarkin, iNaturalist, www.inaturalist.org/observations/101156836.

Invasive *Phragmites* and its Lookalikes

The most reliable morphological traits for distinguishing native from invasive *Phragmites* are listed below. Note that characteristics may vary in field, hybridization is possible, and that genetic analysis is the most reliable method for distinguishing between the two species. In addition, *Miscanthus* (*M. sinensis, M. sacchariflorus*), dubbed "the next *Phragmites*", is an invasive reed-like grass that often grows alongside invasive *Phragmites*. *Miscanthus* forms dense clumps, is shorter (1.2 - 3.6 m tall), seed heads are fan-shaped, change in colour from red to pink, then silver-tan when mature.

	Invasive *Phragmites* *(Phragmites australis)* INVASIVE	**Native *Phragmites*** *(Phragmites australis* subsp. *americanus)* NATIVE
	 Photo courtesy of Lauren Bell.	 Photo courtesy of Lynn Short.
Stand Height	• Up to 5 m	• No taller than 3 m
Stand Density	• Generally high density, near monoculture stands of living and dead stems (up to 200 m^2)	• Generally low density, fewer dead stems and interspersed with native vegetation
Stems	• Generally, dull tan or beige with a rough texture • Stems tend to grow taller (typically 5 m or more) and are wider	• Generally shorter and thinner, shiny with a reddish-brown colour in the lower internodes and a smooth texture
Leaves	• Typically blue-green • **Thin, less distinct ligule (≤ 0.15 mm, excluding hairy fringe)*** • **Greying dead stems are still mostly covered with leaf sheath after growing season***	• Tend to be more of a yellow-green • **Thicker, smudgy ligule (> 0.35 mm), excluding hairy fringe)*** • **Greying dead stems are mostly bare (leaf sheaths will often fall off in fall-winter)***

	Invasive *Phragmites* *(Phragmites australis)* INVASIVE	Native *Phragmites* *(Phragmites australis* subsp. *americanus)* NATIVE
	 Photo courtesy of Lauren Bell.	 Photo courtesy of Lynn Short.
Seed heads	• Large, dense seed heads with spikelets having typically shorter glumes and lemmas • Lower glume: 2.5 - 5.0 mm (most < 4.0) • Upper glume: 4.5 - 7.5 mm (most < 6.0)	• Smaller seed heads and spikelets with longer glumes and lemmas • Lower glume: 3.5 - 6.5 mm (most > 4.0) • Upper glume: 5.5 - 11.0 mm (most > 6.0)
Other Lower glume length + leaf length	• **Lower glume < 4.6 mm*** • **Leaf length > 37 cm**	• **Lower glume > 4.6 mm*** • **Lower glume < 4.6 mm AND leaf length < 37 cm**

Top field traits (in* ***bold**) adapted from McTavish et al. 2023.*

Biology and Life Cycle

In general, growth of invasive *Phragmites* follows these timelines however exact timing will be site-dependent:

- **Dormant:** November-March (stalks remain standing through the winter);
- **Germination:** April-May;
- **Primary vegetative growth:** June-July;
- **Flowering:** August-September;
- **Translocation of nutrients:** September-October (stalks start to die-back, however, leaves remain green and the plant still produces biomass).

Habitat

Invasive *Phragmites* grows in aquatic, semi-aquatic and wetland habitats. It thrives in disturbed habitats, including roadsides and ditches. It prefers standing water found in wetlands and wet fields, on banks, lakeshores, beaches; its extensive root system enables it to grow in a wide range of habitats in Ontario, including low water areas and dry areas. It is very salt-tolerant, allowing it to thrive along roadsides and in ditches where other plant species cannot survive. However, it is sensitive to conditions such as drought, low oxygen, and dynamic aquatic environments with water level fluctuations (e.g., including tidal systems and hydro control areas with daily fluctuations), which can limit the viability of seeds and rhizome fragments.

Pathways of Spread

Invasive *Phragmites* grows in dense monocultures, spreading through underground rhizomes, aboveground stolons and through seed production. However, it spreads to new areas most commonly by rhizome growth and fragmentation. Mature plants can produce thousands of seeds annually, although seed viability is variable from year to year. Once established, populations expand through vigorous growth of underground rhizomes and above-ground stolons.

Plant parts can be transported through natural pathways (e.g., wind, water and/or animal movement). High winds and wave action along shorelines displace and transport fragments of *Phragmites* to new areas where they can colonize. *Phragmites* can also spread via human activity, including in mud on boots, tires or equipment such as ATVs, boats and construction machinery. Construction and highway maintenance activities can transport soil and plant material long distances. Roads are highly effective dispersal mechanisms because they increase landscape connectivity. Plant parts can also be transported and spread if used as camouflage to create or conceal hunting blinds by waterfowl hunters or if collected for ornamental use in autumn floral arrangements.

Distribution

In Ontario, invasive *Phragmites* occurs mostly in the southern part of the province, particularly in roadside ditches, along shorelines, and in interior wetlands and ponds, with scattered occurrences in Georgian Bay, Lake Superior and as far north as Cochrane and Fort Frances. The spread of Phragmites can often be traced along highway corridors. In Canada, it occurs in all provinces and territories, with the exceptions of Yukon and Nunavut. In the United States, *Phragmites* occurs in 48 states. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Invasive *Phragmites* has a wide range of impacts to environmental, cultural and economic values. The impacts on wetlands can be very significant. It spreads aggressively, forming large, dense monocultures. It can reach heights of more than 5 m and densities of over 200 stems/m^2, resulting in loss of native vegetation such as cattails, bulrushes

and sedges. It also releases toxins from its roots, which prevents native plants from growing nearby and may permanently alter the soil. These impacts degrade wildlife habitat and threatens at least 25 % of Ontario's Species at Risk (SAR).

Further non-ecological impacts include:

- Damage to infrastructure;
- Human safety hazards (e.g., dead stands create fire hazards and block sightlines along roadways, etc.);
- Delays and increased cost in construction activities;
- Aesthetic degradation and blocking of property views;
- Reduced property values;
- Loss of medicines and Indigenous cultural keystone species;
- Loss of productivity in woodlots and agriculture;
- Impeding access to important infrastructure and utilities (e.g. fire hydrants, hydro corridors, storm water management infrastructure);

Control Measures

The prevention and early detection of *Phragmites* is essential for long term success. Management is most effective when an IPM approach is taken, using a combination of control tactics (e.g., herbicide application, cutting, prescribed burn) rather than on their own. Committing funds and resources for successive years, especially in well-established stands, will yield better results. Regardless of the control method, management activities may disturb native plants, fish, wildlife and Species at Risk. To minimize potential impacts to these species and their habitats, control activities should be strategically timed to reduce disruption and threat to wildlife, and other mitigative actions should be taken. The Ontario Invasive Plant Council's Best Management Practices document for Invasive Phragmites provides some guidance on timing windows to consider. Be sure to confirm that *Phragmites* stands are of the invasive subspecies and not the desired native species. The proper removal and disposal of plant biomass following control, while limiting further spread via rhizomes, stolons, or seeds, is also important. Biomass removal will improve access to the site for follow-up control and expedites the establishment of native plants.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to prevent the spread of aquatic invasive plants.

Manual Control

Selective Cutting/Spading on Land:

This control method, also called "spading", involves manually cutting *Phragmites* stalks below the sediment surface where it is growing in sand or other soft substrates. This will reduce photosynthesis and deprive the belowground structures of energy. Spading is the most effective control option if the use of herbicides is not advisable and is ideal for selective control of *Phragmites* in sensitive habitats. Using a sharpened spade or other cutting tool, the *Phragmites* stalk should be cut below the soil surface, where the stalk attaches to the underground rhizome.

For more information on this method consult this spading infographic.

Selective Cutting/Spading in Water:

Selective cutting of *Phragmites* beneath the waterline (i.e., at the lakebed or sediment) can effectively drown the plant by inhibiting the supply of oxygen to lower plant parts. In suitable water depths, after cutting has occurred, new shoots cannot successfully reach the surface to collect oxygen. This method can be applied at small and large scales using handheld tools or amphibious cutting vehicles to cut stems. It is the most effective control option if herbicides are not advisable. All cut stalks must be removed from the water to reduce further spread.

For more information on this method consult this cut-to-drown infographic.

Mechanical Control

Mowing/Cutting:

Mowing or cutting *Phragmites* may help curtail stand density and plant rigour but will not kill the belowground structures. Once a cutting program is discontinued *Phragmites* will re-establish, and cutting only a portion of a cell will not curtail spread or stand establishment. Cutting plants after they have developed viable seed heads increases spread. It is therefore not effective as a stand-alone treatment unless combined with herbicide application. Cutting however must be timed appropriately with herbicide application as cutting before herbicide application, or too soon after herbicide application reduces effectiveness.

Cultural Control

Cultural Practices:

This method uses re-vegetation to encourage the growth of native or ground covering plant species with the intention of providing resistance to the invasion of unwanted plants species. In situations such as roadsides and other heavily modified habitats, planting of competitive native grasses, forbs, and woody plants after successful *Phragmites* management may help to diminish seed germination and further spread. This technique is best applied once *Phragmites* has been removed from the site. Site-appropriate aggressive native plants should be selected, and ideally several different species included.

Flooding:

Flooding can be an effective management tool; it acts as a stressor to *Phragmites* by reducing the amount of oxygen that can travel to the root system in high water conditions. Low oxygen levels can decrease the growth of the plant or cause die-off. Some observations indicate that Phragmites is intolerant of dynamic environments, for example where hydro facilities or other infrastructures frequently change water levels. Alternatively, this technique could also be used in natural environments where changing water levels can be predicted.

Prescribed Burning:

This is the planned and deliberate use of fire by authorized personnel and is best used in combination with other management techniques (i.e., herbicide application) as part of an IPM plan. The role of fire is to remove the biomass that restricts native vegetation and to allow for easier herbicide treatments of residual plants the following season. The maximum benefit from fire is obtained when it is done a minimum of three weeks after herbicide treatment, following mowing. This ensures the herbicide has had enough time to translocate to the root and rhizome structures and cause mortality to the plant. Prescribed burning without the prior use of herbicides is not an effective control method. Burning should never be conducted on dead stands of invasive *Phragmites* because fire containment is difficult. The timing for burning should take into account wildlife presence, even

in ditches. Prescribed burns should only occur between late fall and early spring, before wildlife, such as birds, begin to nest. All necessary permits must be obtained and regulations followed when conducting prescribed burning.

Biological Control

Biological control (biocontrol") may become a promising additional tool in *Phragmites* management. Two stem-boring noctuid moths (*Archanara neurica* and *Lenisa geminipuncta*) have been approved for release in Canada and are currently being trialed in Ontario.

Chemical Control

Herbicide application can be an effective method to manage *Phragmites* stands when used in accordance with the label, with appropriate authorization and permits, and when an integrated pest management (IPM) approach is applied. Herbicides can cover large, expansive populations quickly and effectively, with less physical disturbance. There are herbicides available for control of *Phragmites* both over dry land and water, however herbicides may not always be appropriate for a project site. In order to avoid impacting sensitive habitats for species at risk, it is recommended to restrict herbicide application to late summer or early fall. Herbicide application is most effective when combined with manual/cultural removal (such as cutting, rolling, or burning), either before or after treatment depending on the site.

Control Techniques that are **NOT RECOMMENDED:**

- **Manual-Cutting seed heads:** laborious, time-consuming, does not impact rhizome system. Use if only option to control spread.
- **Mechanical-Excavating:** expensive, time-consuming, likely to be unsuccessful. Likely to leave plant fragments behind, causes disturbance to soil.
- **Cultural-Tarping:** laborious, expensive, requires continual monitoring.
- **Cultural-Grazing:** not suitable for sensitive sites, does not impact rhizome system, creates disturbance, can increase *Phragmites* growth and stem density if done at wrong time of year, expensive.

See the Ontario Invasive Plant Council's Best Management Practices Guide on Invasive Phragmites and the Best Management Practice Technical Document for more information this invasive plant and control methods.

See also the *Phragmites* Strategic Framework for Coordinated Management in Ontario.

Purple loosestrife can colonize a wide variety of habitats, including fields.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/64721190.

Purple Loosestrife
(Lythrum salicaria)

Regulatory Status under Ontario's ISA: Not Regulated.

Introduction

Type of aquatic plant: Emergent, wetland plant.

Other names: It is also known as loosestrife or spike loosestrife and is a member of the Lythraceae (Loosestrife) family.

Area of origin, introduction date and location: Purple loosestrife is native to Europe and Asia and was introduced to northeastern North America in the early 1800s. By 1985, it was recorded in several USA states and southern provinces of Canada.

Identification

Size and Stem:

Erect, square (rarely 5 or 6 sided), have short hairs and are reddish to purplish in colour. New growth is typically green. They are woody at the base. It can grow 1 - 3 m tall. It can be unbranched, but plants typically have branches in the mid to lower part of the stem. Purple loosestrife grows a dense root crown, which produces as many as 50 stems per plant.

Leaves:

Opposite or whorls of 3. They are 3 - 10 cm long, lance or egg-shaped, have smooth margins stalkless (attached directly to the stem).

Flowers:

Occur in a dense terminal spike (cluster) that are composed of many flowers and measures up 1 m long. The flowers have 5 - 7 petals that are pink to purplish in colour, but many also be white or magenta and measure 10 mm long. The petals appear to be wrinkly upon closer inspection. They bloom from July to September.

Fruits:

Oval-shaped capsules that measure 2 - 3 mm long. They contain many small seeds. Each stem can produce between 900 - 1000 capsules.

Roots:

Taproot and spreading root stock.

Purple loosestrife can grow between 1 - 3 m tall.

Photo courtesy of Linda Haugen, USDA Forest Service, Bugwood.org.

The stem is erect, square with short hairs.

Photo courtesy of Rob Routledge, iNaturalist, https://www.invasive.org/browse/detail.cfm?imgnum=5445973.

The leaves are opposite or whorls of 3. They are lance or egg-shaped and stalkless.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/57737739.

Flowers occur in a dense terminal spikes, composed of many pink to purplish flowers.

Photo courtesy of Breck Haining, iNaturalist, www.inaturalist.org/observations/238326004.

The fruits are oval-shaped capsule.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/37376234. Licensed under CC-BY-NC.

Purple Loosestrife and its Lookalikes

	Purple Loosestrife *(Lythrum salicaria)* INVASIVE	Fireweed *(Chamerion [syn. Epilobium] angustifolium)* NATIVE	Winged Loosestrife *(Lythrum alatum)* NATIVE	Swamp Loosestrife *(Decodon verticillatus)* NATIVE
	 Photo courtesy of Eric Coombs, Oregon Department of Agriculture, Bugwood.org.	 Photo courtesy of: iNaturalist, www.inaturalist.org/observations/8877766. Licensed under CC-BY-NC	 Photo courtesy of Ruth Metterhausen, www.inaturalist.org/observations/87603232, licensed under CC-BY-NC	 Photo courtesy of iNaturalist, www.inaturalist.org/observations/200145077, licensed under CC-BY-NC.
Plant Type	• Emergent	• Emergent	• Emergent	• Emergent
Stems	• 1 - 3 m, erect • Square or angular, occasionally with 5 - 6 sides • Smooth or hairy • Reddish to purplish • **Numerous stems arising from 1 rootstalk**	• Up to 2 m, erect • Square • Rough-haired • Green or reddish	• Up to 1 m, erect • Square • Hairless • **Raised ridges ("wings") that run parallel the length of stems**	• Up to 2.5 m, erect • 4 - 6 sides • Hairy, lower stem woody, sometimes thick and spongy • Pinkish red • **Long and arching**

	Purple Loosestrife *(Lythrum salicaria)* INVASIVE	Fireweed *(Chamerion [syn. Epilobium] angustifolium)* NATIVE	Winged Loosestrife *(Lythrum alatum)* NATIVE	Swamp Loosestrife *(Decodon verticillatus)* NATIVE
	 Photo courtesy of Eric Coombs, Oregon Department of Agriculture, Bugwood.org.	 Photo courtesy of: iNaturalist, www.inaturalist.org/observations/8877766. Licensed under CC-BY-NC	 Photo courtesy of Ruth Metterhausen, www.inaturalist.org/observations/87603232, licensed under CC-BY-NC	 Photo courtesy of iNaturalist, www.inaturalist.org/observations/200145077, licensed under CC-BY-NC.
Leaves	• Opposite or whorled • **No petiole** • 3 - 10 cm long • Lance to egg-shaped, **rounded base** • Smooth margins • **Hairy surface**	• Alternate • Stalkless or short stalks • 3 - 20 cm long • Linear to lance- shaped • Smooth or slightly wavy margins • Hairless • **Midrib (midvein) white**	• Upper alternate, lower opposite • Stalked • Lower leaves up to 5 cm long, decreases in size as they move up the stem • Ovate or lance- shaped, rounded at base	• Opposite or whorls of 3 - 4 • Short-stalked • 1 - 4 cm long • Lance-shaped, **tapered at both ends** • Smooth margins • Smooth on upper surface, finely hairy on lower surface
Flowers/Fruit	• **Spike-like clusters, 10 - 40 cm long** • Pink-purple • Funnel-shaped, 15 - 20 mm wide • **5 - 7 petals** • Capsule, 6 mm long	• **Terminal raceme** up to 60 cm long • Pink/magenta • **4 broad paddle-shaped petals,** 15 - 30 mm wide • Capsule, 2.5 - 7.5 cm long • **Seeds bear a plume of white silky hairs**	• **Solitary** • Pink-purple borne in the leaf axis • **6 petals,** 4 - 13 mm • Capsule, 1 mm long	• **Dense clusters,** 1.5 cm long • Pink-purple • Triangular sepals • 20 - 25 mm wide • **Round capsule,** 4 - 6 mm across

Biology and Life Cycle

Purple loosestrife is a perennial plant that grows from a persistent tap root and spreading root stock. The large taproot develops early in the seedling stage. When the plant matures, the taproot and major root branches become thick and woody. It reproduces almost exclusively via seed and a single plant can produce between 900 - 1000 capsules with 83 - 130 seeds per capsule, thereby one plant can produce up to 27,000 seeds. Germination occurs only when the soil surface temperature is between 15 °C and 20 °C which happens in late spring or early summer in temperate regions. Germination rates are high (up to 92%). Seeds can remain viable, up to 80%, after 2 - 3 years in the soil. Flowering occurs from July to October. In its northern distribution, purple loosestrife shows earlier flowering timing (approximately 20 days earlier) compared to other parts of its range, which has been found to increase its survival. Seed dispersal is the primary reproductive method, however, it can also produce new shoots from pieces of root or damaged plants. The plants can produce an extensive seed bank in a short period of time and can remain viable in the soil for many years after being shed.

Habitat

Purple loosestrife can tolerate a wide range of ecological conditions, however, it has a preference for wet sites can be found in riparian areas, mudflats, fen meadows, swamps, wetlands, wet fields and ditches. It can grow on a variety of soil textures. It is an early successional species the readily colonizes disturbed or open sites with exposed soil, such as after a flood event. Seeds require open, moist substrates to germinate and once established, it can persist under different condition at that site.

Pathways of Spread

Purple loosestrife was intentionally introduced to North America as a medicinal plant and as an ornamental plant for gardens. It is still widely available as a horticultural plant and it may be planted near or along shorelines and can escape into new areas when plant material is discarded into a nearby waterway or carried off by flooding during a rain event. Seeds are buoyant and can be spread over great distances by water. They can also spread via wind. Highways and road maintenance can contribute to the spread of purple loosestrife. Road construction creates disturbed sites for loosestrife to invade and construction equipment can transport seeds to non-invaded areas. It can also spread through the dispersal of seeds and rhizomes fragments through water, air, or animal movement, or being transported with boats, trailers and other equipment such as fishing gear.

Distribution

In Ontario, it is present throughout all of southern and central Ontario, and has spread further north within the Lake Superior and Rainy River/Winnipeg River watersheds, as well as to Northeastern Ontario. Purple loosestrife has a very widespread distribution; it is found in all of the provinces in Canada (no territories) and all states in the United States with the exception of Arkansas, Florida and South Carolina. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org

Impacts

Purple loosestrife can quickly become dominant in wetland and cause significant changes in wetland vegetation which can alter nutrient cycling often leading to eutrophication of waterbodies. Dense stands can trap sediment which can alter habitat type, changing wet environments to dryer habitats. It forms dense monocultures that often lower the biomass of

native plants. It quickly adapts to a wide range of environmental conditions, expanding its range to out-compete native vegetation for nutrients and sunlight, reducing habitat for native fish, mammals, birds, and species at risk. For example, many marsh birds avoid nesting and foraging in purple loosestrife stands. The flowers of purple loosestrife attract pollinators away from native species. Purple loosestrife can lower the forage value of meadows and outcompete plants that have cultural value such as wild rice. Purple loosestrife often outnumbers native species in the soil seedbank and seeds germinate much faster (with 3 - 4 days) and have higher germination rates. This allows the plant to quickly colonize an area. It can also reduce the availability of hunting and trapping grounds, decrease land values, and have an impact on agriculture. Despite its negative impacts, purple loosestrife has value as a medicinal herb. Its roots were historically uses to treat chronic diarrhea, dysentery, bleeding, wounds, ulcers and sores.

Control Measures

Early detection of purple loosestrife is critical and will greatly increase effectiveness of control. The best time to control purple loosestrife is between late June and early August, when it is in flower. Plants are easily recognizable and it has not yet gone to seed. Control should not occur after it has gone to seed, as there is very high potential to unintentionally spread its seeds. Ideal habitat, such as undisturbed wetlands and disturbed sites such as ditches, should be monitored frequently during the months of July and August. Purple loosestrife can establish an extensive seedbank, which enables the plant to re-establish for several years. As such, it requires management for at least three years. Biological control of purple loosestrife typically the most effective option when this plant becomes established and can assist in the long terms management of this invasive plant. Follow-up monitoring is key to successful control.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to report and prevent the spread of aquatic invasive plants.

Manual Control

Hand Pulling or Digging:

Small populations (< 100 plants) or individual plants can be hand pulled. This can help prevent the establishment of dense monocultures. It is easier to hand-pull younger plants, however, larger plants can be dug out using a garden fork. Hand pulling is most effective when a stand is under two years old as larger plants have a very tough and persistent taproot that will be more difficult to remove. Plants are most easily removed when the soil is moist. Removal can be performed throughout the summer and even when the plant is in flower but must be done before it goes to seed. If hand pulling during flowering, cutting off the flower/seed head into a bag helps prevent the spread of seeds. Using gloves, grip the base of the plant and gently pull it up. It is important to avoid breaking the taproot which encourages re-sprouting. The entire root system must be removed from the soil to prevent re-sprouting It is also important to minimize soil disturbance to avoid bringing seeds to upper soil layers where they may germinate. Plants, especially roots and seeds, should be bagged and not left to decompose on site as purple loosestrife can also regenerate from small fragments. Clean boots, clothes and other equipment before moving to another site.

Mechanical Control

Cutting:

Cutting the above portion of purple loosestrife can prevent flowering and seed spread. This method is non-selective and requires all cut plant parts to be removed, as purple loosestrife can, with sufficient moisture, regenerate from stem fragments. Cutting is more effective later in the season to prevent plants from going to seed. It must be repeated regularly until the plants' energy stores are exhausted as plants can continue to produce flowers. Cutting of purple loosestrife within three weeks of flowering should destroy the seed crop and prevent additions to the seed bank. Bag all plant parts and remove from site as purple loosestrife can regrow from small root and stem fragments. All equipment must be washed before it leaves the site to prevent spread to new areas.

Cultural Control

Tarping:

Covering the infestation with a tarp (or opaque material where sunlight cannot penetrate) can be effective at slowing down growth and seed dispersal. The tarp must extend at least 2 metres beyond the infestation and be weighted down. Monitor the edges of the tarp several times throughout the growing season and remove any regrowth.

Biological Control

The most effective long-term solution for controlling large widespread infestations of purple loosestrife is a biological control. In 1992, both the Canadian and U.S. Governments approved the release of the leaf-feeding beetles, *Galerucella calmariensis* and *G. pusilla*, natural enemies of Purple loosestrife that damage the root system, stunt growth and reduce seed production. These leaf-eating beetles are host specific to purple loosestrife-they need it to complete their life cycle, which makes them such an effective and safe control agent. They have now been used in Ontario for over 20 years through various partnerships, effectively reducing populations. They can reduce populations up to 90% and allow native plants to re-establish. Consult this document for more information: https://bugwoodcloud.org/resource/files/6225.pdf.

Chemical Control

Herbicides provide short-term control of small infestations or isolated plants, but may be impractical and uneconomical against large infestations and there are no pesticides registered for use over water in Ontario at this time. Although there are many herbicides registered for control of purple loosestrife, they can only be applied when surface water is not present, which greatly limits their usefulness as a control measure since this plant occurs in wet environments. See the product label for details on timing of application, intervals of treatment, and concentrations. Note that only those with the appropriate aquatic pesticide exterminator license are permitted to use this product, and a permit may be required.

Control Techniques that are **NOT RECOMMENDED:**

- Mowing is not recommended because it breaks up the plant and can facilitate spread since purple loosestrife can regrow from stem fragments. Prescribed burning is not effective because the plants rootstock is at least two centimeters below the soil surface and much of it in wet (and therefore protected) substrate. Plants recover within ten days.

See the Ontario Invasive Plant Council's Best Management Practices Guide on Purple Loosestrife **for more information this invasive plant and control methods.**

Dense root mats of rough mannagrass trap sediment and alter water flow. In this photo it has infilled a small tributary along the Credit River, Mississauga.

Photo courtesy of Vicki Simkovic.

Rough Mannagrass
(Glyceria maxima)

Regulatory Status under Ontario's ISA: Not Regulated.

Introduction

Type of aquatic plant: Tall, perennial wetland plant (grass).

Other names: It is a member of the Poaceae (Grass) family and also known as reed mannagrass, reed meadowgrass and reed sweetgrass.

Area of origin, introduction date and location: Mannagrass is native to temperate Eurasia. The first North American record of mannagrass came from a marsh in Cootes Paradise, Hamilton in the mid-1940s, but it was likely already present for decades.

Identification

Plant Type:

Emergent

Size and Stem:

1 - 2.5 m tall. Stems unbranched, erect, lower parts reddish.

Leaves:

Leaf blades are quite long (30 - 60 cm), alternate, flat, pointed, shallowly grooved with prominent midribs and visible transverse veins. They are bright green but sometimes tinged with red. Leaf margins have short, stiff hairs that are rough to the touch. Ligules are unlobed, membranous, smooth, obtuse in shape, 1.2 - 6 mm long.

Flowers:

Flowers can appear in long, stiff open panicles (openly branched) or be contracted and symmetrical. The panicle branches have short, stiff hairs like those on the leaf margins. Flowers June to August.

Fruits:

Seeds are small, 1.5 - 2 mm long, egg-shaped, smooth and dark brown, with a deep and narrow central furrow (groove in the seed).

Roots:

Root are fibrous, 1 - 2 mm diameter, several arising from each rhizome node, extending to depths of 1 m.

Flowering stalks are 1 - 2.5 m tall, erect and unbranched.

Photos courtesy of A. Reuven Martin, iNaturalist, www.inaturalist.org/observations/14560313.

Flowers are in long open panicles openly branched).

Photo courtesy of Joanne Muis Redwood, iNaturalist, www.inaturalist.org/observations/57561004.

Leaves have a prominent midrib. Ligules are unlobed, membranous, smooth, obtuse in shape.

Photo courtesy of Joanne Muis Redwood, iNaturalist, www.inaturalist.org/observations/57561004.

Leaves are alternate along the stem. Closed leaf sheaths have an angular bend. Reddish near base of stem.

Photo courtesy of Pat Deacon, iNaturalist, www.inaturalist.org/observations/117989857.

Mannagrass and its Lookalikes

	Rough Mannagrass (*Glyceria maxima*) INVASIVE	American Mannagrass (*Glyceria grandis*) NATIVE
	 Photo courtesy of Leslie J. Mehrhoff, University of Connecticut, Bugwood.org.	 Photo courtesy of Wasyl Bakowsky.
Plant Type	• Emergent	• Emergent
Stalks	• 1 to 2.5 m in height **(can be taller)**	• Up to 1.5 m in height **(can be shorter)**
Leaves	• Lower leaf sheaths **rough** in texture (scabrous)	• Lower leaf sheaths are **smooth**
Flowers/Fruit	• **Open panicle branches are more stiff** • **Longer glumes (3 - 4 mm long)** • Flowers from June to August	• **Open panicle branches are more lax** • **Shorter glumes (1.5 - 2.7 mm long)** • Flowers from June to August

Biology and Life Cycle

Mannagrass emerges early in the year, giving it a competitive advantage over other native plants. It reproduces primarily through vegetative means, rhizome growth and fragmentation. Its extensive root system can extend up to depths of 1 m and comprises 40 - 55% of the plant's total biomass. These rhizomes can produce vast numbers of shoots that quickly expand the colony size initially, but growth slows in mature stands and in deep water. It goes dormant in winter, overwintering as small green shoots, and in early spring, regrowth occurs from rhizome buds. Plants flower in spring and summer and produce high seed numbers after their second year. While many of these seeds can germinate immediately and produce many vigorous shoots, others remain dormant for several years in the seedbank. Seeds typically do not establish well in mature, dense stands, as the dense cover of matted weeds hinder seed establishment. Seeds are most likely to colonize new areas if they establish on wet, bare mud, perhaps transported on the feet of wading birds.

Habitat

Mannagrass can colonize a wide variety of wet habitats including marshes, wetlands, along shorelines of lakes, rivers and streams, canals and drainage ditches. It prefers waterlogged soils with direct sunlight but can grow in partially shaded areas adjacent to woodlands. It can expand into shallow water and survive prolonged flooding because of its aerenchyma and superficial root system, and can grow in deep water up to depths of 1.5 m. When growing near open water it can form floating mats along the bank. It is more likely to be found in soils high in total phosphorous and nitrogen.

Pathways of Spread

Mannagrass can be spread when foraging wildlife, such as muskrats and beavers, uproot portions of the rhizomes which then float downstream and establish in new areas. Seeds are viable and can float downstream or stick to mud on machinery or livestock. Rhizomes can fragment and spread during flooding events. Established colonies continue to spread by their creeping rhizomes. The variegated form, *Glyceria maxima* var. *variegata* is still available for purchase as an ornamental plant in gardens.

Distribution

In Ontario it is widespread and locally abundant from Sarnia in southwestern Ontario to Ottawa in southeastern Ontario, with scattered records elsewhere in Ontario, including north to Huron Shores and Algoma. Extensive patches can be seen in ditches and roadside wetlands along Highway 7 between Peterborough and Ottawa, and along the banks of the Credit River in Mississauga. It is also abundant in the Wye Marsh near Midland. In Canada, it has also been found in British Columbia and Newfoundland. In the United States, it can be found in Alaska, Wisconsin, and Massachusetts, with recent reports in Washington and Illinois. It has also been reported to be invasive in parts of Australia, New Zealand and the United Kingdom. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Since its initial discovery at Cootes Paradise in the mid 1940s, it has spread to many wetland habitats in Ontario, where it has overtaken native cattails and other species as the dominant emergent plant. Mannagrass can significantly impact wetlands by forming large dense monocultures along shoreline edges. In deep water, it can form floating mats that attach to the shoreline. Its extensive system of roots and rhizomes outcompete and suppress native wetland plants. These thick root mats also trap sediment and alter the water flow, restricting or clogging small waterways and drainage systems, and can contribute to flooding. Mannagrass is a poor

food source and nesting site for many wetland wildlife species. Although it has been used as forage, cattle may experience cyanide poisoning if allowed to graze on young shoots.

Control Measures

Management is most effective when an IPM approach is taken, using a combination of control tactics (e.g., herbicide application, cutting, prescribed burn) rather than on their own. Populations may require 2 - 3 years of treatment for complete control. Regardless of the control method, management activities may disturb native plants, fish, wildlife and Species at Risk. To minimize potential impacts to these species and their habitats, control activities should be timed to reduce disruption and threat to wildlife, and other mitigative actions should be taken. The proper removal and disposal of plant biomass following control, while limiting further spread via rhizomes, stolons, or seeds, is also important. Remove dead plant material after control to prevent biomass accumulating in water and dissolved oxygen levels from decreasing.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to report and prevent the spread of aquatic invasive plants.

Manual Control

Digging:

Individual plants or small infestations can be dug, making sure to remove all roots and rhizome pieces. It is very difficult to remove the entire rhizome system, therefore complete eradication is unlikely. Repeat digging for 2 - 3 years to remove leftover rhizome fragments.

Mechanical Control

Mowing or Cutting:

Vegetative spread of larger populations can be controlled by repeat mowing, cutting or harvesting. Mowing or cutting several times through the growing season may deplete energy reserves in the rhizomes, reducing its competitive ability and allowing other competitive vegetation to expand into the site. Be sure to mow or cut prior to seed set to prevent further spread. Cutting in the fall when carbohydrates and nutrients are stored for the winter may affect spring regrowth.

Cultural Control

Tarping:

Tarping may be an effective method of controlling small, dense populations of mannagrass. Be sure to leave the tarp in place for at least 5 - 6 weeks.

Cultural Practices

Mannagrass is sensitive to shade and appears to be out-competed once there is adequate cover of overstory vegetation. Restoration of competitive native riparian vegetation that can out-shade mannagrass could be an effective long-term consideration. Site-appropriate aggressive native plants should be selected, and ideally several different species included.

Biological Control

There are no known biological control agents for this species.

Chemical Control

On drier sites, mannagrass could be foliar sprayed with glyphosate in the early to late summer. Imazapyr in summer or early fall and when water levels are low and plant stems are not submerged.

Water fern (A. *filiculoides*) invasion in Höchstadt, Germany, giving the water surface a red appearance.

Photo courtesy of Paul Hackney.

Water Ferns
(Azolla spp.*) (A. filiculoides, A. cristata, A. pinnata)*

Regulatory Status under Ontario's ISA: Restricted.

It is illegal to import, deposit, release, breed/grow, buy, sell, lease or trade this restricted invasive species in Ontario. It is also illegal to bring a restricted species into a provincial park or conservation reserve and to possess, transport, deposit or release them in these protected areas.

Introduction

Type of aquatic plant: Free-floating, aquatic plant (fern).

Other names: Water ferns, or *Azolla* spp. are members of the Salvinaceae (Floating Fern) family. The taxonomy of this genus is a subject of confusion, contradiction, and debate. There are three recognized species present in North America that will be the focus of this document:

- **Large mosquito fern (A. *filiculoides*)**
  - Also known as water fern, large mosquito fern, duckweed fern, fern azolla, Pacific azolla, Pacific mosquito fern, red azolla, redwater fern. A. *caroliniana* and A. *microphylla* are synonyms.
- **Eastern mosquito fern (A. *cristata*)**
  - Also known as Atlantic azolla, Carolina azolla, Carolina mosquito fern, water velvet. *A. caroliniana* and *A. mexicana* are synonyms.
- **Feathered mosquito fern (A. *pinnata*)**
  - Also known as feathered mosquito fern, African azolla, ferny azolla, water velvet.

Area of origin, introduction date and location: These species are native to parts of North America, South America, Africa, and Asia, but have spread outside their traditional range to areas of North America, Central America, Oceania, Africa, and Asia.

Identification

Size and Stem:

Water ferns are reduced and specialized in form, resembling some mosses or duckweeds rather than true ferns. All species form a dense mat-like covering on the water's surface. Individual plants are small and consist of a short, branching, floating stem with alternatively arranged leaves.

Leaves (fronds):

Leaves (called fronds in fern species) overlap, with a waxy, water-repellant surface that is velvety and scale-like in appearance. The leaves have an upper green (i.e., photosynthetic) lobe which bears hydrophobic hairs, and a smaller, usually colorless lobe, which is buoyant and often submersed. The leaves of some species, like *A. cristata*, can turn red or rust color in winter or bright environments. This can give a red color to the surface of waterbodies they have invaded.

Roots:

Thread-like, unbranched roots are produced from the axils of branches.

Some species can turn red or rust-color.

Photo courtesy of Jennifer Chandler, iNaturalist, www.inaturalist.org/observations/69563441.

Water ferns are small, with thread-like, unbranched roots.

Photo courtesy of Ron Vanderhoff, iNaturalist, www.inaturalist.org/observations/58081661.

Water ferns float on the water's surface.

Photo courtesy of Robin Ellison, iNaturalist, www.inaturalist.org/photos/228231241.

Leaves overlap, have waxy, water-repellant surface.

Photo courtesy of Ron Vanderhoff, iNaturalist, www.inaturalist.org/observations/58081661.

Biology and Life Cycle

Water ferns are small aquatic ferns, whose overlapping scale-like leaves float on the waters surface. Its roots hang vertically in the water, absorbing nutrients directly from the water, or soil if the roots contact soil in shallow water. Water ferns are capable of rapid growth, doubling in size within 4 - 5 days in optimal conditions. Its rapid growth and spread is mainly through vegetative reproduction, by elongation and fragmentation of the small fronds. They are also capable of sexual reproduction under favorable environmental conditions (warm, humid conditions), where spores are released into the water. While many species prefer tropical or subtropical environments, *A. filiculoides* may have evolved cold tolerant strains that can survive temperatures as low as -10 °C before death occurs.

Habitat

Water ferns prefer still, protected, open water sites, such as slow-moving streams, ponds, marshes, swamps, and lakes. They can also be found floating on the water's surface in irrigation channels, reservoirs, and ditches. Large mosquito fern (*A. filiculoides*) prefers warm, tropical climates with humid summers and mild winters, similar to its native range. Water ferns are well-known for their unique symbiosis with the nitrogen-fixing cyanobacterium (blue-green alga) *Trichormus azollae*, found in cavities in the upper leaf lobes. This relationship gives it the ability to thrive in nitrogen-poor water bodies. Since phosphorus is the limiting factor, eutrophic conditions (i.e., due to agricultural run off) can lead to *Azolla* blooms.

Pathways of Spread

Water ferns have been distributed globally through commercial trade as an aquarium and ornamental plant, although these species are now prohibited under the *Invasive Species Act* (ISA). It has also been introduced intentionally for its socioeconomic benefits, such as decreasing mosquito populations or use as a bio fertilizer in rice paddies. However, populations can become invasive and negatively impact biodiversity and ecosystem function. Once established, it is easy for vegetative fragments and spores to float downstream or be carried by floodwaters into new areas. Small fragments can adhere to animals such as water birds, amphibians, and rodents, or adhere to humans, boats and other recreational equipment, and spread to new areas.

Distribution

- **Large mosquito fern (*A. filiculoides*)**
  - Native to western North America, including the Rocky Mountain states of the western USA, as well as most of Central and South America. It is thought to have been introduced into southern BC, and potential introductions have occurred in parts of Ontario in the past, including Hamilton (in 1862), Gananoque (in 1981), central Ottawa (in 1997), although there are no recent detections. Globally, it has been introduced to Europe, North and sub-Saharan Africa, China, Japan, New Zealand, Australia, the Caribbean and Hawaii.
- **Eastern mosquito fern (*A. cristata*)**
  - Has been introduced to parts of Africa, Asia, and Europe, and is considered invasive in South Africa, India, and Japan. It is native to the eastern United States. In Canada, this species is found in small, isolated pockets of Ontario, where it is presumed to be native in the Frontenac Axis of Leeds and Grenville County, as well as western Lake Ontario (Hamilton and Niagara Peninsula). Populations found in the Rideau and Ottawa rivers in Quebec and in southern British Columbia may be introduced.
- **Feathered mosquito fern (*A. pinnata*)**
  - Native to Africa, Asia, and Australia (mainly a tropical species). Introduced into the United States where it is classified as a noxious weed or prohibited in several states and it is considered invasive in New Zealand. The climate in Ontario may be too cold for *A. pinnata* to establish.

The uncertainty over taxonomic status of water fern species makes determining their precise native and non-native ranges challenging.

Impacts

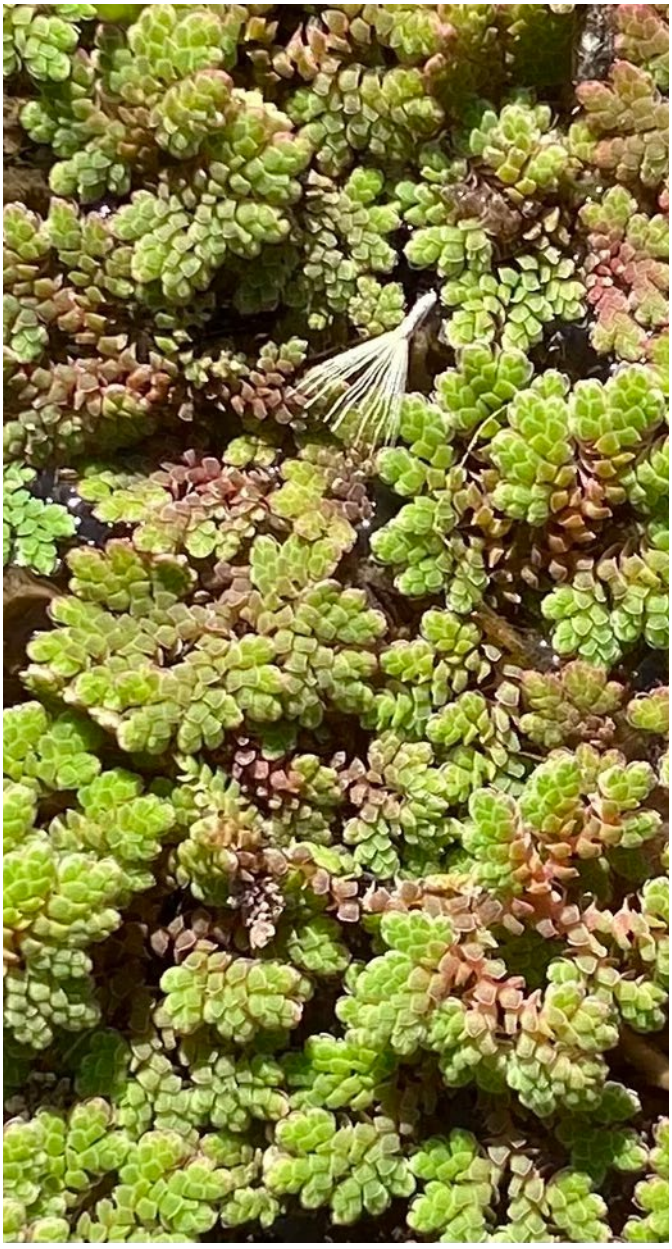
Water ferns can grow rapidly, forming overlapping, dense mats 5 - 20 cm thick, and expanding outwards by several hectares in ideal conditions (especially eutrophic waters). The dense mats reduce light and oxygen which outcompetes native aquatic plants and alters pH and other physiochemical variables. The anaerobic environment created by dense mats can negatively impact drinking water quality. Dense mats can clog irrigation and flood control structures and reduce suitable water surface area for recreational activities such as fishing, boating and swimming.

Despite their potential to be highly invasive, water ferns have had important socio-cultural uses for centuries. Their nitrogen-fixing ability has led to its use as a biofertilizer, especially in southeast Asia, where it is planted in rice paddies to suppress weed growth, and release nitrogen into the water from die-back to benefit rice plants. It was also used to control mosquito larvae in rice fields, which is how its name 'mosquito fern' was coined, based on the belief that no mosquito can penetrate the coating of fern to lay its eggs in the water.

Control Measures

There are no invasive populations of water fern in Ontario, however populations are very difficult to eradicate once established. As a prohibited species under the *Invasive Species Act* (ISA), prevention and early detection are prioritized. Learn the key characteristics for identifying water ferns (*Azolla* spp.) and differentiating them from lookalikes. It may be necessary to obtain a sample to differentiate to species level. Samples can then be eradicated by drying or freezing all live plant material, placing it in a plastic bag, and disposing of it in a landfill. Refer to section Prevent the Spread (**page 6**) for details on how to prevent the spread of aquatic invasive plants.

If you think you've seen any species of water fern in Ontario, take a picture, record the location and contact the Invading Species Hotline to report it. For more information and guidance call the **Invading Species Hotline at 1-800-563-7711** or visit www.invadingspecies.com or www.ontarioinvasiveplants.ca.



A. filiculoides in Phoenix, Arizona.

Photo courtesy of Matt Chew, iNaturalist, www.inaturalist.org/observations/190097303. Licensed under CC-by-NC.

In warmer parts of the world, water hyacinth spreads rapidly in a short amount of time.

Photo courtesy of Karen Brown, University of Florida, Bugwood.org.

Water Hyacinth
(Eichhornia crassipes)

Regulatory Status under Ontario's ISA: Not Regulated.

Introduction

Type of aquatic plant: Floating, aquatic plant.

Other names: It is a member of the Pontederiaceae (Pickerel-weed) family and is also known as common water hyacinth.

Area of origin, introduction date and location: It is native to the Amazon River in South America and was first introduced to North America in Louisiana in 1884 where it was initially cultivated as an ornamental plant due to its striking flowers. It is important to note that while there are isolated sightings in the wild in Ontario, there has neither been confirmed seed production in Ontario, nor confirmed evidence of successful overwintering and establishment.

Identification

Size and Stem:

Forms a rosette that are linked by stolons (horizontal stems). Typically 60 - 120 cm tall.

Leaves:

Thick and shiny, with a waterproof coating that gives them a glossy look. They are roundish or elliptic with a curved top and a rounded, cylindrical base. They measure 15 cm wide. The petioles (leaf stalks) are inflated and up to 30 cm long which helps the plant float. There are typically 6 - 8 leaves per plant.

Flowers:

Emergent and occur in a single spike with 8 - 15 flowers, measuring up to 30 cm long. The flowers are violet-blue in colour with three sepals, and the petals, with one petal having a darkened middle area and a yellow spot. Flowers appear between early spring and late fall.

Fruits:

A 3-seeded capsule with many seeds.

Roots:

Long, and dark purple to black, which float freely in the water column, but may root in very shallow or soft sediments. They are 10 - 300 cm long.

Water hyacinth is a rosette that is linked by stolons.

Photos courtesy of A. iNaturalist, www.inaturalist.org/observations/80960842.

The leaves are thick, shiny, and rounded. Petioles are inflated.

Photo courtesy of Don Marsille, iNaturalist, www.inaturalist.org/observations/105610146.

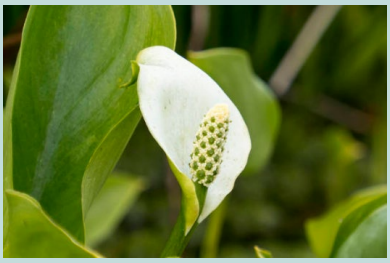
Flowers occur in a single spike with 8 - 15 violet-blue flowers.

Photo courtesy of Edson Guilherme, iNaturalist, www.inaturalist.org/observations/11242862.

The roots are long, dark purple to black.

Photo courtesy of Hope Abercrombie, iNaturalist. www.inaturalist.org/observations/165062002. Licensed under CC-BY-NC.

Water Hyacinth and its Lookalikes

	Water Hyacinth *(Eichhornia crassipes)* INVASIVE	Water Arum *(Calla palustris)* NATIVE	Pickerelweed *(Pontederia cordata)* NATIVE
	 Photo courtesy Wilfredo Robles, Mississippi State University, Bugwood.org.	 Photo courtesy of Wolfgang Bettighofer, iNaturalist, www.inaturalist.org/observations/48244190, licensed under CC-BY-NC.	 Photo courtesy of Wasyl Bakowsky.
Plant Type	• Floating	• Emergent	• Emergent
Stalks	• **NA**	• Erect	• Erect
Leaves	• Floating or emergent • Form a rosette • Thick, glossy, **egg-shaped to round** • Up to 11 cm long • Petiole 3.5 - 33 cm, **usually inflated**	• Thick, glossy, **heart-shaped** • **Edges curl inwards** • 5 - 20 cm long • **Leaf stalk sheathed at base**	• **Mainly basal (growing from the lowest part of the stem)** • **1 large leaf,** 5 - 25 cm long, 2 - 15 cm wide • Lance to egg-shaped, heart-shaped, blunt tipped and glossy
Flowers/Fruit	• Violet-blue, **upper petal with darkened area and yellow spot** • Spike, 4 - 15 flowers per inflorescence • 6 petals • 12 - 37 cm long	• **Creamy-white** • Cylindrical spike **surrounded by a petal-like spathe** • 7 - 30 cm long	• Violet-blue **with 2 yellow dots on upper lip** • Form a dense, hairy, stalked spike above large bract • **2 lipped, 0.8 mm long** • 5 -15 cm long
Stolons	• Extend outward from the plant to produce new plants; readily break apart from one another	• Extend outward from the plant to produce new plants; readily break apart from one another	• NA

Biology and Life Cycle

Water hyacinth spreads by both seed and vegetative reproduction. However, seeds remain dormant for up to 20 years until conditions are favourable for germination. Seeds are produced in capsule and each capsule can hold up to 300 seeds. Water hyacinth is killed by freezing temperatures, so any new growth in spring depends on the seed bank from the previous growing season and the right conditions for germination. Germination is typically encouraged by aerobic (oxygenated water) and alternating temperatures. Once seeds have germinated, water hyacinth rapidly produces new plants from stolons, and populations can double in size in a matter of a few days. Vegetative reproduction is the main mode of population increase, and a single plant can rapidly create a new colony. Low nutrient and temperatures are the strongest factors affecting the growth of water hyacinth.

Habitat

Water hyacinth can grow in almost any aquatic habitat, provided it is rich in nutrients (eutrophic). It can be found in ponds, rivers, canals, and wet ditches and is able to survive fluctuating water levels. Optimal temperature for growth is 25 - 30 °C, but is can tolerate short periods of freezing. It is typically found in waters with a neutral pH (7) but it can also be found in waters with a pH between 6 - 8 and can tolerate low levels of salinity.

Pathways of Spread

Water hyacinth is still commonly sold as an ornamental plant in ponds and outdoor water gardens which is the primary vector of spread. Once introduced, it can spread through wind and water currents and seeds can be transported long distances by birds. It can spread between water bodies through plant material (seeds or plant parts) that are transported with boats, trailers, fishing gear, or other equipment.

Distribution

Isolated populations of this plant have been found throughout southern Ontario, including the Durham Region, Barrie and Buckhorn and eastern Ontario (Belleville, Napanee). Between 1998 and 2001, it was also found in west Lake Erie (Pelee Island), with populations consisting of 2,000 - 5,000 plants. To date, there has been no evidence of it overwintering, this may be because of the cooler climate. The species is not generally considered to be cold-tolerant, and its ability to survive, overwinter and successfully reproduce self-sustaining populations in the wild in Ontario has not been demonstrated. Large populations of water hyacinth have been found in warmer southern parts of the United States, including areas surrounding the Gulf of Mexico and California. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

In other parts of the world, water hyacinth grows and spreads rapidly over large areas. It forms dense, floating, tangled mats of vegetation, which reduce oxygen in the water, and shade out native aquatic plant species, reducing their diversity. These mats which are also referred to as tussocks, sudds and floatants, can accelerate succession, creating an environment for emergent and terrestrial plant species. It can dramatically alter an ecosystem leading to degradation and a reduction of biodiversity of plants and other aquatic organisms such as phytoplankton. These dense mats of vegetation can also restrict waterflow and evapotranspiration rates, which degrade water quality, reduces irrigation channels and can increase the risk of flooding. Water hyacinth can impede navigation and recreational use of waterways, and may increase still water pools for mosquitos to breed in. The mats can also impact infrastructure, by blocking irrigation canals and hydro/water plant intake pipes.

Despite its negative impacts, water hyacinth can be used for bioremediation, vermicomposting, compost production, biofuel production, animal feed production and as a medicinal herb.

Control Measures

There are currently no known self-sustaining established populations of water hyacinth in Ontario. If you think you've seen water hyacinth or another invasive species in the wild, please take a picture, record the location and contact the toll free **Invading Species Hotline at 1-800-563-7711**, visit EDDMapS www.eddmaps.org, or search for the 'Invasive Species in Ontario' project on iNaturalist www.inaturalist.org to report a sighting.

Water hyacinth is very difficult to control once it becomes established, thus the best course of action for control is early detection and rapid response. It has a very persistent seed bank where one plant can produce 3,000 seeds which can remain viable between 5 - 30 years in suitable conditions. Thus, management will need to be repeated over several years to exhaust the seed bank. That being said, control should take place before plants flowers to prevent seed set. On-going monitoring over several growing season is needed. Manual control is only suitable for small populations as fragmentation can cause the plant to regenerate. Larger infestation can be controlled through mechanical harvesting or chemical control (when permitted). There is some evidence that water drawdown can control small populations in enclosed waterways where water levels can be manipulated. Chemical control may not be an option depending on potential impacts to the environment, being an ecologically sensitive area or when the chemical has low absorption by the invasive plant.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to prevent the spread of aquatic invasive plants.

Manual Control

Hand Removal:

Small infestation of water hyacinth can be removed by hand. This should be done before the plant flowers and produces seed (October). Water hyacinth can survive for long periods of time on moist banks and should not be left to decompose on these sites.

Mechanical Control

Mechanical Harvesting:

Large infestation of water hyacinth can be removed using handheld equipment such as weed cutters and machinery such as mechanical harvesters. With large and established populations, the thick dense mats can be heavy and challenging to remove. Often, mechanical harvesters will need to be used to detach the mat from the edge of the infestation.

Cultural Control

Water-level Control:

In areas where water levels can be controlled (i.e., landlocked ponds, irrigation channels, reservoirs), lowering water levels can be an effective management strategy. The germination of water hyacinth seeds is stimulated in muddy, moist and shallow waters. Lowering the water level to less than 1 m, can stimulate a mass germination event. Following this, seedlings can be manually removed (before flowering) or an herbicide can be applied. This is recommended for small areas (hand removal) or in areas where an herbicide can be applied promptly.

Biological Control

There are currently no biological control option available to control water hyacinth in Canada. Two weevils show promise to control this plant in other parts of its range.

Chemical Control

Large infestations of water hyacinth can be controlled with herbicides. However, this may cause negative environmental impacts, including lowering the diversity of native plant species. Currently there are two herbicides registered to control water hyacinth in Canada whose active ingredients are acrolein and methoprene respectively. See the product label for details on timing of application, intervals of treatment, and concentrations. Note that only those with the appropriate aquatic pesticide exterminator license are permitted to use this product, and a permit may be required.

It should be noted that spraying an entire infestation of water hyacinth can cause the plant to sink which can lower water quality. It is recommended to spray in strips or mechanically remove as much of the plant as possible before spraying.

Water Hyacinth has thick, glossy leaves, an air bladder, and long hanging roots.

Photo courtesy of Richard Old.

Water Lettuce forms dense mats, reducing oxygen levels, which can kill fish.

Photo courtesy of Karen Brown, University of Florida, Bugwood.org.

Water Lettuce
(Pistia stratiotes)

Regulatory Status under Ontario's ISA: Not Regulated.

Introduction

Type of aquatic plant: Free-floating, aquatic plant.

Other names: It is a member of the in the Araceae (Arum) family.

Area of origin, introduction date and location: It is native to South America, Africa, and Asia and was first reported in North America in the mid-1700s along the St. Johns River in Florida.

Identification

Size and Stem:

Resembles an open head of lettuce floating on the water. Its floating leaves form a tight rosette and do not have stems. It measures 6 - 30 cm wide and 15 cm long. They can be connected by stolons (horizontal stem structure).

Leaves:

Thick, velvety, spongy, light green and have prominent ridges (7 - 15) running parallel to each other. The leaves are rounded at the top and 2 - 20 cm in length.

Flowers:

Small and white to pale green.

Fruits:

Berries (2 mm long) that are green when immature and become brown as they mature. They contain up to 20 tiny, golden-brown seeds.

Roots:

Submerged and hang beneath the rosette of the leaves. They are long, tan which float freely in the water column. They measure between 50 - 80 cm long.

Resembles an open head of lettuce. Its leaves form a tight rosette.

Photo courtesy of Brent Franklin, iNaturalist, www.inaturalist.org/observations/1946414.

The leaves are thick, velvety, spongy, light green and have prominent ridges.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/42610662.

Flowers are small and white to pale green.

Photo courtesy of Leslie J. Mehrhoff, https://www.invasive.org/browse/detail.cfm?imgnum=5273076.

The roots are submerged and hang beneath the leaves. They are long and tan-coloured.

Photo courtesy of Fabian Jaramillo, iNaturalist, www.inaturalist.org/observations/218810083.

Water Lettuce and its Lookalikes

	Water Lettuce *(Pistia stratiodes)* INVASIVE	Water Hyacinth *(Eichhornia crassipes)* INVASIVE
	 Photo courtesy of Troy Evans, Bugwood.org.	 Katherine Parys, USDA-ARS, Bugwood.org
Plant Type	• Floating	• Floating
Leaves	• Floating, or nearly erect • Forms a rosette • **Blade simple, spongy, leaf apically rounded and narrowed at the base** • Light green with **short white hairs and prominent veins** • 2-20 cm long	• Floating or emergent • Form a rosette • Thick, **glossy, egg-shaped to round** • Bright green • Petiole 3.5-33 cm, usuallyinflated • Up to 11 cm long
Flowers/Fruit	• **Small and white to pale green on small stalk from rosette** • Single female flower below and single whorl of male flowers above • **Fruit is a green berry turns brown at maturity**	• **Violet-blue with 2 yellow dots on upper lip** • **Form a dense, hairy, stalked spike above large bract** • **Fruit is a capsule**
Stolons	• Extend outward from plant to produce new plants	Extend outward from plant to produce new plants; readily break apart from one another
Roots	• Numerous roots hang beneath rosette of leaves; 50 cm in length	• Dark purple to black • Long and feathery, hang beneath rosette of leaves; up to 1 m long

Biology and Life Cycle

Water lettuce is hardy plant that is well known in sub-tropical and south temperate areas of the United States as a vigorously growing perennial. In northern temperate climates, its ability to successfully overwinter is not well understood. Adult plants generally will die with the onset of frost and freezing temperatures. However, there may be the potential for plants to survive in the future with a warming climate. Despite this, water lettuce can grow extensively within the spring and summer seasons, with each plant producing vegetative offshoots that are connected to the mother plant by. In Ontario, there is no evidence that water lettuce reproduces through seed. It is believed that the main reason for reoccurrence of water lettuce in consecutive years in certain lakes in Ontario is from annual introduction.

Habitat

Water lettuce grows in slow-moving waters and can be found in streams, rivers, ditches, lakes, ponds, and canals. It is not winter hardy and is limited in temperate regions by long, cool winters. Its minimum growth temperature is 15 °C and its optimum temperature for growth ranges between 22 - 30 °C. It is typically found in freshwater as it has low salinity tolerance.

Pathways of Spread

Water lettuce is common in the aquarium and water garden trade. It can be introduced to natural areas from intentional plantings, from plant material being discarded into a waterway, or from being carried off by flooding during rain events. It can also spread between waterbodies from plant material, such as rosettes attached to boats, trailers or equipment.

Distribution

In Ontario, water lettuce has been found in the Rideau Canal in Ottawa, along the Welland Canal in the Niagara Region, in the Lake Simcoe watershed, and has also been found co-occurring with water hyacinth in Lake St Clair. It is believed that the main reason for recurrence of water lettuce in consecutive years in certain lakes in Ontario is from annual introduction by local residents, rather than from successful reproduction. The species is not generally considered to be cold-tolerant, and its ability to survive, overwinter and successfully reproduce self-sustaining populations in the wild in Ontario has not been demonstrated. In Canada, it has also been found in Hubley Lake near Halifax, Nova Scotia. In the United States, it is found in 19 states. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Under favourable growing conditions, water lettuce forms large, dense floating mats of vegetation, which can restrict water flow, interfere with irrigation or infrastructure (e.g., hydroelectric/ water treatment facilities) and impede recreational activities such as boating, fishing, and swimming. These dense mats of vegetation also reduce oxygen levels in the water and cause high evapotranspiration rates, impacting fish and other aquatic organisms. Water lettuce produces a compound that can interfere with the growth processes of algae. Dense mats outcompete native aquatic plants, reducing biodiversity and they can also create ideal breeding habitat for mosquitoes. It changes both the physiochemical characteristics of a waterbody including nutrient levels, water velocity, pH and plankton diversity.

Despite this, water lettuce has potential for bioremediation as it can accumulate heavy metals from wastewater.

Control Measures

There are currently no known self-sustaining established populations of water lettuce in Ontario. If you think you've seen water hyacinth or another invasive species in the wild, please take a picture, record the location and contact the toll free **Invading Species Hotline at 1-800-563-7711**, visit EDDMapS www.eddmaps.org, or search for the 'Invasive Species in Ontario' project on iNaturalist www.inaturalist.org to report a sighting.

Early detection and rapid response is key to prevent the establishment of water lettuce. An integrated pest management (IPM) approach should be used. Plants cannot survive for long periods out of water which makes hand removal, mechanical harvesting and water drawdowns effective. Small infestations can be hand-pulled prior to the plants producing flowers and seeds. This is impractical for larger infestations. While larger infestations can be removed through mechanical harvesting, caution must be taken to prevent the spread of the plant through fragmentation. In some instances, larger populations that occur as a thick mat which may have to be cut into smaller sections. It is recommended to surround the infestation with netting or a commercial curtain to contain the plants and prevent them from spreading. Some success has been seen by deploying floating diversion booms in slow moving waters to prevent the spread of the plant downstream. Control must be repeated for several years.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (**page 6)** for details on how to prevent the spread of aquatic invasive plants.

Manual Control

Hand Removal:

Small populations of water lettuce can be removed by hand before the plants flower and produce seeds. It is easiest to control water lettuce when the infestation is small.

Mechanical Control

Mechanical Harvesting:

Large populations of water lettuce can be harvested. Plants cannot survive for long out of water. However, water lettuce breaks apart very easily. Thus, effort must be made to contain the infestation and prevent the spread of plant fragments using netting or a commercial curtain. Large mats may need to be cut into smaller sections in order to remove the plants. Harvesting can negatively impact native plant biodiversity and increase turbidity and should not be used in ecologically sensitive areas.

Cultural Control

Water-level control:

Drawing down the water level can only be conducted in areas where the water levels are controllable. It is not a possibility for public waters, but could be used in small landlocked ponds or reservoirs. For this control measure to be effective, the plants must become stranded on dry land.

Biological

There is no biological control option available for water lettuce in Canada. In South America, two weevil species, *Neohydronomus* affinis and *Argentinorhynchus* breyeri show promise as biological control agents.

Chemical Control

There are currently no approved herbicides for water lettuce in Canada.

Watermosses can form mats up to 2 m thick.

Photo courtesy of Barry Rive, www.sarracenia.com, Bugwood.org.

Watermosses-*Salvinia* spp.
(S. molesta, S. auriculata, S. minima, S. natans)

Regulatory Status under Ontario's ISA: Prohibited.

It is illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade this prohibited invasive species in Ontario.

Introduction

Type of aquatic plant: Floating, aquatic plant.

Other names: Four species of *Salvinia* have been introduced into the United States, all are members of the Salvinaceae (Floating Fern) family. The accepted and alternate names of each species include:

- **Giant salvinia (*Salvinia molesta*):** Kariba-weed, water fern, giant azolla.
- **Eared watermoss (*S. auriculata*):** African payal and butterfly fern.
- **Common salvinia (*S. minima*):** Water spangles.
- **Floating Fern (*S. natans*):** Floating watermoss, floating moss, and water butterfly wings.

Area of origin, introduction date and location:

- **Giant salvinia (*Salvinia molesta*):** Native to Brazil, has become established in over 20 countries.
- **Eared watermoss (S. *auriculata*):** Native to Central and South America including Mexico south to Argentina and Chile.
- **Common salvinia (S. *minima*):** Native to South America, Mesoamerica, and the West Indies.
- **Floating Fern (S. *natans*):** Has the largest native distribution, including Asia, central Europe, Africa, and South America.

***Note:** *All watermoss species share similar identification features, life cycles, habitats and impacts.*

Identification

Watermosses are difficult to identify to species level, requiring identification of small details under the microscope. A general description of the *Salvinia* genus is provided, should a positive identification be made of any member of this group.

Size and Stem:

All watermosses produce submerged leaves on a root-like stem that floats below the water's surface. Stems are creeping, branched, with hairs.

Leaves:

In whorls of three, two paired floating leaves on the surface, one leaf submerged. Floating leaves are green, simple, rounded to elliptic-ovate, up to 4 cm long, distinct midvein, with a short petiole or without. Leaves lie flat but crowding when grown in full sun crumples leaves and makes them vertical, resembling squashed grapes. The upper surface of the leaves is water repellent, covered with distinctive white hairs, hairs are forked and can be shaped like an eggbeater. Submerged leaves are root-like, finely dissected, with a petiole, brown.

Flowers:

All watermosses lack flowers.

Fruits:

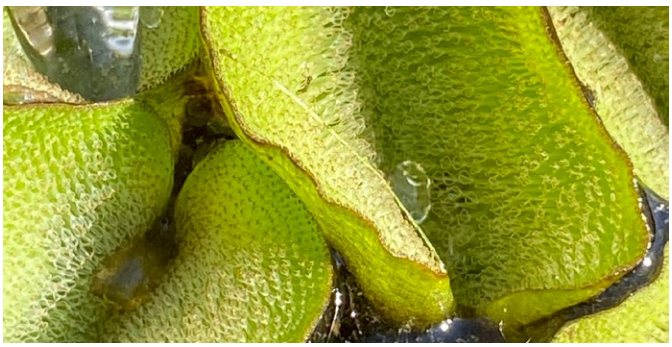
A 3-seeded capsule with many seeds.

Roots:

All watermosses lack true roots as they are free-floating plants. The underwater root structure conceals stalks that can have infertile egg-shaped spore cases.

All watermosses have leaves that are rounded, simple, with distinct midvein.

Photos courtesy of WM-leaves. James Kuria, iNaturalist, www.inaturalist.org/observations/206922119.



Leaves are covered with distinct hydrophobic hairs.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/116579549.

Hydrophobic hairs are forked and can be shaped like an egg-beater.

Photo courtesy of Connor Keeney, iNaturalist, www.inaturalist.org/observations/108000138.

Underwater root structure with egg-shaped spore cases.

Photo courtesy of Benny Wu, iNaturalist, www.inaturalist.org/observations/239132496.

Watermoss and its Lookalikes

	Watermoss *(Salvinia spp.)* INVASIVE	Great Duckweed *(Spirodela polyrhiza)* NATIVE
	 Photo courtesy of Julien Piolain, www.inaturalist.org/observations/255311903.	 Photo courtesy of iNaturalist, www.inaturalist.org/observations/53055421.
Plant Type	• Floating	• Floating
Leaves	• 3 in a whorl, but appear paired with 2 floating, 1 submerged • Floating leaves green, simple, rounded, 4 cm in diameter • Flat, entire, short-petioled or no petiole • Upper surface with erect forked hairs • Submerged leaves root-like, finely dissected with petiole	• Floating leaves • Small, bright green above, lower surface red to purple, simple, rounded to oval • Flattened, entire, no petiole, obscurely nerved • 2 - 8 mm long • Single or in large colonies
Flowers/Fruit	• Not present	• Rare, a tiny ribbed seed, 1.5 mm long
Stems	• Creeping, branched, bearing hairs	• N/A
Roots	• N/A	• 5 - 12+ roots that hang below

Biology and Life Cycle

Watermosses can reproduce both sexually via spores and vegetatively. Some species such as *S. auriculata* and *S. natans* reproduce using both methods, while others such as *S. molesta* are vegetative only, producing non-viable spores. Populations are clonal and capable of rapid growth. Each individual (ramet) has a horizontal rhizome with an internode, a node, two floating leaves, and a modified third leaf that serves as a root. Each node supports at least three axillary buds, that can generate new plants. Buds can remain dormant through times of stress and drought and when conditions are optimal, they will grow. In addition, rhizomes fragment easily, and each piece can generate a new plant. The leaves of watermosses float using a unique system of air trapped in egg-beater shaped hairs that grow in parallel rows on the upper surface of leaves.

Distinguishing features of watermosses include their ability for rapid growth and adaptability to conditions beyond their environmental optimal. For example, *S. auriculata* can double the number of leaves on the water surface in only two days in optimal conditions and can spread at a rate of 400 km^2/year. It has different growth forms or phases, including a "colonizer form" or primary phase, where leaves are small and lie flat on the water's surface due to open, uncrowded conditions. The stems are thin and fragment easily, producing many new plants. As the colony matures, the "mat form" or secondary and tertiary stages occur, where the leaves grow larger, thicken, and become compact, almost vertical, and acutely folded. Where growing conditions are ideal, the plant can reach these final stages in 2 - 3 weeks. Optimal growth occurs in nutrient-rich environments, pH 6 - 7.5, and water temperatures between 23 - 29 °C.

Watermosses are very adaptable to adverse environmental conditions. For example, although they are tropical species, they are capable of surviving mild winters in Canada. While air temperatures of about -16 °C for at least 48 hours and/or ice formation on the water's surface is needed for the plant to be killed, it possesses a number of adaptations that allow it to survive frost and temperatures around 0 °C. Thicker mats and larger leaves insulate buds below water from colder air temperatures. During heavy frost, emergent growth may be killed, but buds and submersed stems survive, and regenerate in spring from dormant lateral buds.

Habitat

Watermosses are found in open and still waters, freshwater rivers, lakes, swamps, reservoirs, ditches and water tanks. They are often found sheltered from wave action in small bays, inlets, and tributaries of small streams. They can also survive some dessication on mudbanks.

Distribution

Watermosses are popular in the water garden and aquarium trade and are now distributed globally. Four of these species have been introduced to the United States where they are classified as invasive, with one species (*S. minima*) present in neighboring Great Lakes states. Due to the proximity of these states to Ontario, and Salvinia's ability to live in sub-optimal conditions including colder climates, it is considered a high potential threat for invasion into Canada. Watermoss species are not yet established in Ontario or Canada and are now a prohibited species under the *Invasive Species Act* (ISA). Common salvinia (*S. minima*) was introduced to the United States in the 1920s -1930s, and as of 2022 reported from 14 states, including New York and Massachusetts. Floating fern (*S. natans*) is also found in New York and Massachusetts. Giant salvinia (*S. molesta*) was first detected in South Carolina in 1995, and as of 2022 has been reported in 12 states, mainly concentrated in the southern states such as Texas, Louisiana, and Mississippi.

Eared watermoss (*S. auriculata*) is found in California, where it was first detected in 1999. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Pathways of Spread

Watermosses are sold globally as ornamental plants for the aquarium and water garden trade. While it is now illegal to import, possess, transport, deposit, release, propagate, buy, sell or trade any species in the watermoss or *Salvinia* genus, these plants may still be available illegally in Ontario. They may escape into waterways by accidental or intentional disposal of aquarium and pond contents or arrive as contaminants in imports of other horticultural plants. They can disperse naturally when older rhizomes develop abscission layers and fragment, dispersing protected buds. Buds and rhizome fragments can be dispersed long distances by water currents, flooding, or can attach to boats, boat trailers and recreational equipment, and wildlife.

Impacts

Watermosses pose a significant threat to freshwater ecosystems as they grow rapidly, form dense floating mats that outcompete native vegetation, reduce oxygen content and adversely affect water quality. These dense mats can be up to 1 m thick and can potentially spread across entire lakes or rivers. The thick vegetation impedes traffic flow and recreational use of waterways and may increase still water pools in which mosquitoes can breed. They can impact infrastructure by blocking irrigation canals and hydro/water plant intakes. Giant salvinia (*S. molesta*) is listed in the IUCN's 100 of the world's worst invasive alien species due to its global impact to aquatic ecosystems.

Control Measures

There are no populations of watermoss in Ontario. As a prohibited species under the *Invasive Species Act* (ISA), prevention and early detection are prioritized.

Refer to section Prevent the Spread (p**age 6)** for details on how to prevent the spread of aquatic invasive plants.

If you think you've seen any species of watermoss in Ontario, take a picture, record the location and contact the Invading Species Hotline to report it. For more information and guidance call the **Invading Species Hotline at 1-800-563-7711** or visit www.invadingspecies.com or www.ontarioinvasiveplants.ca.

All watermosses leaves are rounded and flat, with erect, forked hairs on the upper surface.

Photo courtesy of Robert Videki, Doronicum Kft., Bugwood.org.

Water soldier can impede recreational activities such as boating and swimming.

Photo courtesy of Francine McDonald.

Water Soldier
(Stratiotes aloides)

Regulatory Status under Ontario's ISA: Prohibited Species.

It is illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade this prohibited invasive species in Ontario.

Introduction

Type of aquatic plant: Submerged or emergent, aquatic plant. Can become buoyant during the summer months.

Other names: It is a member of the Hydrocharitaceae (Frog-bit) family.

Area of origin, introduction date and location: It is native to Europe and northwest Asia and was first reported in Ontario in 2008 in the Trent River, near the town of Havelock.

Identification

Size and Stem:

Similar in appearance to an aloe plant, spider plant or the top of a pineapple. As the leaves mature and begin to die, they become waterlogged and the plant sinks below the surface. The leaves form a large rosette (a cluster of leaves radiating from a centre point). Mature water soldier plants produce offsets, which are similar to those produced by the household spider plant.

Leaves:

Stalkless, long and thin and sword-shaped with sharp serrated edges. The emergent leaves are thick and rigid and are usually less than 40 cm long. The submerged leaves are thin and brittle, and less than 60 cm long. Some populations only have submerged leaves.

Flowers:

Dioecious (male and female flowers are on different plants). The flowers are emergent with three white petals and a vibrant yellow centre.

Fruits:

Female plants rarely produce 1 - 3.5 cm fleshy berries, each containing 24 seeds. Viable seed has never been found in Ontario.

Roots:

Long, white and thin and loosely hold the plant in the sediment.

Water soldier (left) is similar in appearance to an aloe plant, spider plant or the top of a pineapple. Leaves form large rosette. The rosette (right) can also occur below the surface of the water.

Photos courtesy of (left), Jarosław Krogulec, iNaturalist, www.inaturalist.org/observations/196824142 (right), Denis Davydov, iNaturalist, www.inaturalist.org/observations/171179825.

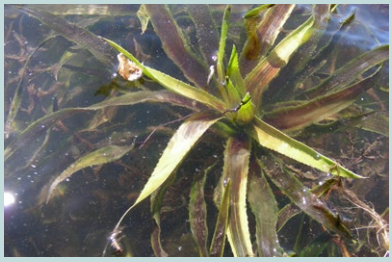
The emergent leaves are stalkless, long, thin and sword-shaped with sharp, serrated edges.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/181890414.

Flowers are small and white to pale green.

Photo courtesy of Aleksandr Ebe, iNaturalist, www.inaturalist.org/observations/38502913. Licensed under CC-BY-NC.

Water Soldier and its Lookalikes

	Water Soldier *(Stratiotes aloides)* INVASIVE	Bur-reed *(Sparganium americanum)* NATIVE	Tapegrass *(Vallisneria americana)* NATIVE
	 Photo courtesy of Eric Snyder.	 Photo courtesy of Robert H. Mohlenbrock, United States Department of Agriculture.	 Photo courtesy of Gary P. Fleming/DCR Natural Heritage.
Plant Type	• Submerged/Emergent	• Emergent	• Submerged
Stalks	• Not present	• Erect; 30 - 90 cm tall • **Light green, grass like**	• Not present
Leaves	• Light to dark green • Stalkless, forming a large rosette • **Linear or narrowly triangular in shape with serrated edges** • **Submerged leaves** thin and brittle (typically); < 60 cm long • Emergent leaves thick and rigid; less < 40 cm long	• Bright green • Stalkless, forming a rosette • Linear, thin, **smooth edges** • Partially submerged • 90 cm long • **Thin and channeled, with parallel veining**	• **Green to red, midvein is lighter colour, giving a 3-striped appearance** • Stalkless, forming a rosette • Linear, thin, rounded tips, **smooth or minutely serrate edges** • Submerged or partially floating • 1 m long, 3 - 10 mm wide
Flowers/Fruit	• **White with yellow centre** • Solitary and emergent • **Fruit berry-like capsule**, ovoid to barrel-shaped, 1 - 3.5 cm long	• **Green** • **Spiky, ball-shaped flower clusters form a zigzag pattern along stem** • **Fruits are bent and grow within bur-like heads of female flower cluster**	• White • Small, solitary • **Male flowers** 3 sepals, 1 - 2 petals, detach from plant and rise to surface • **Female flowers,** 3 sepals and 3 petals • Extend to surface on long, coiled stalks • **Round fruit,** 5 - 12 cm long
Roots	• Long, white, thin • 60 - 80 cm long • Hang free or loosely rooted in sediment	• N/A	• Thick rhizome 2 - 5 mm in length, with numerous roots and nodes spaced 1 - 3.5 cm apart

Biology and Life Cycle

Water soldier is a perennial plant, which reproduces primarily through vegetative means. It is dioecious whereby male and female flowers occur on different plants. It can exist as both a submerged or emergent plant which gives it a competitive advantage because it can occur both above and below the water's surface. All plants, whether they are emergent or submerged will over-winter as submerged plants, with the gas filled leaves of the emergent plants senescing, causing the emergent plants to sink. In May and June, some overwintering plants float to the surface while others stay submerged, this is generally depth dependent with emergent plants only occurring where the water is sufficiently shallow or stagnant.

Vegetative reproduction occurs via offsets and turions. Offsets tend to remain attached to the parent plant, unless detached from physical disturbance and allow for more localized, rapid expansion of the patch size. Turions are produced during the last half of the growing season and are released by the parent plant from August up until ice forms. Turions, when released, will float in moving water which allows for long range dispersal. While turion production is occurring, leaves on the mother plant begin to die and plants sink to the sediment surface. Turions will grow between the leaves of water soldier and then will be released once the leaves surrounding them have fully senesced in the early spring. This strategy of sinking to the bottom allows the plant to overwinter under extreme cold conditions. Water soldier has a number of competitive advantages such as rapid growth in the spring in some populations, ability of vegetation to develop under ice and the ability to form dense, monospecific stands. Only female plants have been detected in North America and there is no known seed production.

Habitat

Water soldier can occur in waters up to 5 m deep, (although it prefers shallow waters 0.5 - 1.5 m in depth) in slow-moving rivers, lakes, ponds and canals It prefers nutrient rich waters and soft, muddy, sediments. It has low salinity tolerance and is limited to freshwater. Declines in abundance have been associated with high alkalinity and excessive concentrations of certain nutrients (bicarbonates, sulphates and ammonium).

Pathways of Spread

Water soldier was used as an ornamental plant in water gardens and private ponds prior to its regulation in Ontario in 2016. This is the likely source of its introduction in Ontario. It can be spread to natural areas through intentional disposal of water garden contents, planting in waterways, or flooding from outdoor ponds into waterways. Once it is introduced, it can spread to new areas through dispersal of plant material (small offsets, and turions) becoming attached to boats, trailers or equipment such as fishing gear or to animals such as birds.

Distribution

The first known and most extensive population of water soldier in the wild within North America is located on the Trent-Severn Waterway in Ontario, near Havelock and was found in 2008, and subsequently has spread downstream to the Bay of Quinte, in the Gananoque River watershed in eastern Ontario, as well as a recently discovered population in Lake Simcoe in 2024 (Metroland Staff 2024). It was also found in the Black River in 2018 on the south side of Lake Simcoe near Sutton, although that population was eradicated. There have also been additional reports in several private in the province-most of which have been controlled to prevent spread to new areas. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Water soldier forms dense mats of floating vegetation, which crowd out native vegetation resulting in decreased plant biodiversity. For example, it can lower the growth rates of duckweed through allelopathy (*Lemna minor*). It can alter water chemistry, impacting aquatic organisms such as phytoplankton and zooplankton. These mats can hinder recreational activities, such as boating, angling and swimming and interfere with infrastructure (e.g., hydroelectric facilities and navigation locks). Sharp serrated leaf edges can cut swimmers and individuals who handle water soldier plants.

Control Measures

Control of water soldier is most effective when using a variety of methods specific to site characteristics and using an integrated pest management approach (i.e., combining hand pulling and herbicide application. Manual removal by hand may be appropriate if the areas to be treated are relatively small (<25 m^2). Control efforts carried out in early spring or late fall, when native plant species are dormant, help minimize impacts on native plant communities. Chemical control using diquat or florpyrauxifen can be effective at controlling water soldier, especially where the areas to be treated are relatively large (> 25 m^2), there is low turbidity, and areas to be treated have sufficient water depth to avoid sediment disturbance.

In Ontario, an inter-agency working group was formed in 2013 to coordinate research, monitoring, control and prevention of water soldier. Each year, sections of the Trent-Severn Waterway are monitored for water soldier from June to August. In 2017, this working group proposed a multi-year strategy to eradicate water soldier in Ontario within five years. Between 2018 - 2020, some areas saw a 70% reduction in water soldier.

It is important to note that water soldier is regulated as a prohibited species under the *Invasive Species Act* (ISA). It is currently illegal to import, possess, deposit, release, transport, breed/grow, buy, sell, lease or trade this species. In order to support the effective management of this species across the province, the Ministry of Natural Resources has developed a Prevention and Response Plan for Water Soldier in Ontario. The Prevention and Response Plan enables people and organizations to undertake low risk activities to monitor, control, and in some cases eradicate, this invasive plant without the need for an authorization under the *Invasive Species Act*. This prevention and response plan identifies the persons or groups of persons who are authorized to implement the plan, sets out the types of activities that the plan applies to and describes conditions that these persons must follow to lawfully possess, transport, and deposit water soldier in Ontario. The plans also include detailed best management practices for this invasive plant. Individuals planning to undertake activities to monitor or control this species should familiarize themselves with the rules and conditions outlined in the Prevention and Response Plan in order to understand whether an authorization under the *Invasive Species Act* may be required.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to prevent the spread of aquatic invasive plants.

Manual Control

Hand Removal:

Water soldier plants tend to be quite large and as a result individual plants and small populations (< 25 m^2) can be effectively controlled by hand-pulling. As opposed to submersed plants like waterweed and water-milfoil, water soldier plants are much less prone to fragmentation. As a result, removal of the mother plants and attached offsets is possible. In dense or large infestations, issues associated with limited visibility and large numbers of small detached offsets/turions may hinder the effectiveness of manual removal. While initial visibility may be quite good, experience suggests that the combination of disturbance and physical removal of plants can create high levels of turbidity that greatly reduce visibility. As a result, repeated removal attempts after the water clears are required to ensure that all of the plants are removed. The best time of year for hand removal is in the spring or early summer (June to mid-July) when water clarity is at its greatest and before water soldier produces turions. Take precautions to prevent the release of plants downstream during control. It is also important to inspect and clean all equipment and watercraft used during control before moving to another site. Water soldier should be disposed of properly on dry-land to ensure that no part of the plant is accidentally re-introduced into the water body.

Note: Hand pulling in late summer and the fall should be avoided because water soldier begins to produce turions and offsets which can potentially be released during control efforts.

Caution: Due to the large size of the plants and associated sharp spines along the margin of the leaves, it is important to wear protective gloves for manual removal.

Mechanical Control

Mechanical Harvesting:

As a large, free-floating aquatic plant, water soldier may be susceptible to harvesting when the plants are either suspended halfway up the water column or when they are floating. Mechanical harvesting might provide an advantage over hand removal in larger areas where water soldier plants are dominant. Development of a water soldier harvesting program would require additional work to determine optimal timing, for example, prior to or following production of offsets and turions. One of the challenges with mechanical harvesting of water soldier is the relative quantity of biomass emergent populations produce, which can be up to 14 kilograms per square metre. This can present significant issues for managing transport of the cut material via barge, and then disposal on land, which may also require off-site transport to another location. Containment of cut areas is also critical to avoid spreading plants or reproductive parts downstream of management areas.

Note that the Prevention and Response Plan for water soldier does not apply to the use of removal activities other than by hand pulling or human-powered hand-held devices (e.g. rake). Persons seeking to remove water soldier through the use of mechanical harvesters must obtain a separate authorization under the *Invasive Species Act* (ISA). Permits may also be required for mechanical harvesting, refer to the Applicable Legislation and Permitting Requirements section for more details.

Raking:

When conducted during the right time of the year (spring-early summer) raking can assist in preventing turion production, and to access plants that are in deeper water. However, at the wrong time of year, raking can result in the breaking off of plant fragments which can include offsets and turions, and contribute to the spread of the plant.

To avoid offset dispersal during raking, a barrier, such as a seine net, should be placed in the water surrounding the work.

Biological Control

Recently, an aquatic moth of the genus *Parapoynx* was observed consuming the leaves of water soldier in the South-Western corner of Percy's Reach in the Trent Severn Waterway. The use of or herbivory upon water soldier by local or native invertebrates or wildlife is a potential area for future research.

Chemical Control

Chemical control of water soldier is effective to control large infestations (> 25 m^2). Diquat-based or Florpyrauxifen-based herbicides are registered for this plant in Canada. See the product label for details on timing of application, intervals of treatment, and concentrations. Note that only those with the appropriate aquatic pesticide exterminator license are permitted to use this product, and a permit may be required.

Water Soldier is also on the label for ProcellaCOR (PCPA Registration No. 34732) and trials have recently taken place testing the use of ProcellaCOR in the Bay of Quinte. ProcellaCOR has now been used twice to control water soldier in the Bay of Quinte, once in a bay North East of Baker Island off Trenton and once in Muscote Bay. In the instance near Trenton Water Soldier biomass was reduced by 100% in the treated area, though it was not necessarily any more effective than diquat (which was compared in the same study).

Yellow floating heart is a floating, aquatic plant. It is rooted to the sediment.

Photo courtesy of Enot Poluskuns , iNaturalist, www.inaturalist.org/observations/137110692, licensed under CC-BY-NC.

Yellow Floating Heart
(Nymphoides peltata)

Regulatory Status under Ontario's ISA: Restricted Species.

It is illegal to import, deposit, release, breed/grow, buy, sell, lease or trade this restricted invasive species in Ontario. It is also illegal to bring a restricted species into a provincial park or conservation reserve and to possess, transport, deposit or release them in these protected areas.

Introduction

Type of aquatic plant: Floating, aquatic plant. Rooted to the sediment.

Other names: Yellow floatingheart, fringed water lily and is a member of the Nymphaeaceae (Water-lily) family.

Area of origin, introduction date and location: Native to Europe, Asia, and the Mediterranean. It was introduced to North America in the late 19th century. It was first recorded in Ontario in 1942 in Sudbury but was also found planted in Ottawa in the 1960s.

Identification

Size and Stem:

Long and branched, typically 2 m long. Stems occur below the surface of the water.

Leaves:

Circular or heart-shaped, 3 - 15 cm long. The leaves are green to yellow-green with slightly wavy margins. They float on the surface of the water and are attached to long stalks that attach to underwater rhizomes. The underside of the leaf is often purple. They are arranged alternately on stolons and oppositely arranged on flower stems.

Flowers:

Solitary or clusters of 2 - 5, bright yellow, 5-petaled flowers arise from the node (where the leaf attaches to the stem. Petals are fringed. They measure 2 - 4 cm in diameter.

Fruits:

"Beaked" capsule that measures 2.5 cm long. They contain numerous, flat, oval-shaped seeds.

Roots:

Long-branched stolons and creeping rhizomes.

Stems are long, branched and typically 2 m long.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/127492792.

Leaves are circular or heart-shaped, green to yellow-green. They float on the surface of the water.

Photo courtesy of Thomas Guggemoos, iNaturalist, www.inaturalist.org/observations/236953319.

Flowers are solitary or in groups of 2 - 5 with 5 bright, yellow petals.

Photo courtesy of Matthieu Gauvain, iNaturalist, www.inaturalist.org/observations/259179054.

Fruits are "beaked" capsules.

Photo courtesy of Olga Chernyagin, iNaturalist, www.inaturalist.org/observations/129793051.
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Yellow Floating Heart and its Lookalikes

	Yellow Floating Heart *(Nymphoides peltata)* INVASIVE	Little Floating-Heart *(Nymphoides cordata)* INVASIVE	White Waterlily *(Nymphea odorata)* NATIVE
	 Photo courtesy of iNaturalist, www.inaturalist.org/observations/54725055, licensed under CC-BY-NC.	 Photo courtesy of Sean Blaney, iNaturalist, www.inaturalist.org/observations/130574872, licensed under CC-BY-NC.	 Photo courtesy of iNaturalist, www.inaturalist.org/observations/55299943, licensed under CC-BY-NC.
Plant Type	• Floating, rooted to sediment	• Floating, rooted to sediment	• Floating
Stems	• Long, branched • Typically 2 m long	• Long, branched • Typically 0.6 m	• Thick and elastic like • Flattened and winged • Up to 2 m long
Leaves	• Circular or heart-shaped • 3 - 15 cm long • Green to yellow-green, lower surface often purple • **Slightly wavy margins** • Attached to long stalks	• **Prominently heart-shaped** • 2.5 - 7.5 cm long • Green, **mottled with red**, lower surface reddish-purplish • Smooth leaf margins • Attached to long stalks	• **Circular** • 5 - 20 cm long • Green, lower surface reddish • Smooth margins • Attached to long stalks
Flowers/Fruit	• **Bright yellow** • Solitary or clusters of 2 - 5 flowers • 5 petals that are fringed • 2 - 4 cm diameter • **Fruit is a beaked capsule**	• White, yellow centre • Solitary • 5 petals that are fringed • < 1.5 cm diameter • **Fruit is a spherical capsule**	• White, yellow centre • Solitary • 20 - 30 petals • 7.5 - 15 cm diameter • **Fruit is round and berry-like**
Rhizomes	• Stolons and rhizomes	• Stolons and rhizomes	• Rhizomes

Biology and Life Cycle

Yellow floating heart is a perennial, floating plant. Its typical growing season is April to October and it overwinters via its rhizomes that become dormant. This plant can reproduce via seeds and vegetatively through rhizomes, stolons and plant fragments. The production of seeds requires cross-pollination between long and short-style flower morphs, but self-pollination has also been documented. Seeds require cold stratification for optimal germination rates and this plant can form a persistent seed bank. It can withstand fluctuating water levels because the petioles (leaf stalks) can quickly elongate with rising water and flex when water levels drop. However, it cannot withstand sudden and extreme water level drops or prolonged periods of desiccation.

Habitat

Yellow floating heart grows in lakes, ponds, swamps and channels with slow moving waters. It can also be found in damp mud, swamps and wetlands. It can grow in waters up to 4 m deep and is able to tolerate low-oxygen (anaerobic) environments.

Pathways of Spread

Yellow floating-heart is a popular ornamental species for ponds and while now illegal to import, possess, transport, deposit, release, propagate, buy, sell or trade, may still be available illegally in Ontario. Many infestations are linked to the intentional planting of this species in water gardens and subsequent spread to lakes and rivers. The seeds of this species can float in water and attach to animals or waterfowl.

Distribution

Yellow floating-heart occurs in several United States and Canadian provinces. It has been reported in Novia Scotia, New Brunswick, Quebec, Alberta and Ontario. In Ontario, yellow-floating heart was reported in a pond that connect to the Rideau River, in Burlington (in the Royal Botanical Gardens Nature Sanctuaries) and in several areas near Georgetown. There are also some sightings in Mississauga and near Dunville For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Yellow floating-heart forms dense floating mats that can outcompete native vegetation and can create stagnant, low-oxygen conditions in the water below. This can degrade fish and wildlife habitat in addition to creating ideal habitats for mosquitoes. As it is rooted into the sediment, it can uptake nutrients from the soil, particularly nitrogen and phosphorus, and release them into the water which can cause eutrophication. This plant can also alter the chemical composition of water through increasing organic content. Dense mats of yellow floating-heart can impede recreational activities such as swimming, boating and fishing and clog navigation and irrigation channels. It also becomes extremely costly to control.

Control Measures

Early detection and rapid response is key to prevent the establishment of yellow floating-heart. Prevention is the most effective way to reduce the spread of this invasive plant on a long-term scale. Management options must be considered carefully to avoid spreading the plant which can reproduce vegetatively. Yellow floating-heart can be challenging to manage because most control efforts risk fragmenting the plant which can lead to it regenerating. Options like mechanical harvesting can make the situation worse. Manual removal, while labour intensive, can be an effective control measure assuming all plant and root fragments are removed to prevent regeneration. Mechanical removal such as hand raking can be used, however, this is only appropriate for small, localized infestations.

Cultural control methods such as benthic barriers can be effective for small areas of yellow floating-heart. Finally large populations are best managed using chemical control.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (**page 6**) for details on how to prevent the spread of aquatic invasive plants.

Regulatory restrictions must also be considered. Benthic barriers are not permitted by Parks Canada for use in the Trent-Severn Waterway or the Rideau Canal. For projects on Provincial Crown land or shore lands, placement of these materials requires a work permit from MNR under the *Public Lands Act* as this control method does not fall under the provincial rules for removing invasive aquatic vegetation in Ontario without a work permit.

This plant is not yet widely established througout Ontario. If you think you've seen yellow floating-heart in Ontario, take a picture, record the location and contact the Invading Species Hotline to report it. For more information and guidance call the **Invading Species Hotline at 1-800-563-7711** or visit www.invadingspecies.com or www.ontarioinvasiveplants.ca.

Manual Control

Hand Removal:

Manual removal can be an effective control method, however, it is often very labor intensive. It is important that all plant and root fragments be removed in order to present the plant from spreading to new areas. Plants should be lifted from underneath the rhizome as this is the most effective method. Manual removal will need to be done multiple times a year to remove seedlings or new sprouts.

Mechanical Control

Raking:

Hand raking can be effective for very small, localized infestations. This method is best used when the ground is loose where plants can be uprooted and removed from the site.

Cultural Control

Benthic Barriers:

Benthic barriers, which are also called bottom mats or bottom barriers, are covers placed on the bottom sediment of a waterbody over an invasive plant population. They can be effective for small areas. These covers prevent light penetration and kill rhizomes through trapping toxic compounds. It is important to use heavy PVC pond liners (18 oz or PVC vinyl). The benthic barrier should extend 20 cm beyond the edge of the infestation. If using multiple liners is required to cover the entire infestation, it is important that they overlap by at least 15 cm and be connected using 50 cm spikes with washers to have no open seams where the rhizomes can penetrate. Barriers need to be secured to the sediment using bricks or rocks.

Biological Control

There are currently no approved biological control agents for yellow floating-heart in North America.

Chemical Control

Large infestations of yellow floating-heart can be controlled with herbicides. Currently, there is a newer, more selective herbicide for controlling yellow floating-heart in Canada called ProcellaCOR FX (PCPA Registration No. 34732).

Control Techniques that are **NOT RECOMMENDED**:

- Mechanical harvesting can fragment the plant, increasing the likelihood of spread to new locations.

Yellow Iris forms dense stands of vegetation, displacing native vegetation.

Photo courtesy of Dawn Sucee.

Yellow Iris
(Iris pseudacorus)

Regulatory Status under Ontario's ISA: Not Regulated.

Introduction

Type of aquatic plant: Emergent, aquatic plant.

Other names: It is a member of the Iridaceae (Iris) family, and is also known as pale yellow iris, yellow water iris or yellow flag.

Area of origin, introduction date and location: It was first introduced to North America as a horticultural plant, with the first observation in Canada in Newfoundland in 1911 and in Ontario in 1940.

Identification

Size and Stem:

Solid, erect and unbranched. It can grow between 0.4 - 1.5 m tall.

Leaves:

Broad, flattened, stiff and sword-shaped. They are flattened at the base and fan out. The measure 50 - 100 cm long and 10 - 30 mm wide.

Flowers:

Pale yellow to orange with six segments. Three drooping sepals are tongue-shaped and yellow with purple veins and spots at the base (5 - 7.5 cm wide and 3 - 4 cm long). Three erect petals are smaller (2 - 3 cm long) and yellow.

Fruits:

Glossy-green, leathery, 6-sided, oblong capsule (4 - 8 cm long and 5 - 8 mm wide). Each capsule can have 100 - 120 small, brown, disc-shaped seeds.

Roots:

An extensive underground root system of branching, thick rhizomes. They exude a black sap that is toxic if ingested and can cause skin irritation.

Yellow iris is an emergent, aquatic plant with solid, erect stems and can grow between 0.4 - 1.5 m tall.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/111697253.

The leaves are broad, flattened and sword-shaped, measuring 50 - 100 cm long.

Photo courtesy of iNaturalist, www.inaturalist.org/observations/127262717.

The flowers are pale yellow to orange with three drooping sepals (tongued shaped, yellow with purple veins at base) and three erect petals (yellow).

Photo courtesy of Oleg Kosterin, iNaturalist, www.inaturalist.org/observations/48134077.

The fruit is a glossy-green, leathery, 6-sided capsule.

Photo courtesy of Nomfusi Ntsobi, iNaturalist, www.inaturalist.org/observations/150482923.

An extensive underground root system of thick rhizomes that exude a black sap.

Photo courtesy of Leslie J. Mehrhoff, https://www.invasive.org/browse/detail.cfm?imgnum=5453133. Licensed under CC-BY-NC.

Yellow Iris and its Lookalikes

	Yellow Iris *(Iris pseudacorus)* INVASIVE	Harlequin Blue Flag Iris *(Iris versicolor)* NATIVE	Cattail *(Typha spp.)* NATIVE/INVASIVE	Burreed *(Sparganium spp.)* NATIVE
	 Photo courtesy of Wasyl Bakowsky.	 Photo courtesy of Sally and Andy Wasowski, Wildflower.org.	 Photo courtesy of Robert L. Stone, Wildflower.org.	 Photo courtesy of iNaturalist, www.inaturalist.org/observations/170051495, licensed under CC-BY-NC.
Plant Type	• Emergent	• Emergent	• Emergent	• Emergent
Stems	• Solid, 70 - 150 cm tall	• 20 - 80 cm tall	• Over 1 m tall, from spreading rhizomes	• Solid, 0.3 - 2.1 m
Leaves	• Erect, linear, sword-shaped • 40 - 100 cm long, 2 - 3 cm wide • Parallel veined	• Linear, elongated, with parallel veins • **Up to 3 cm wide, as long as stem**	• Flat, 10 - 25 mm wide (Narrow-leaved only 5 - 10 mm wide), spongy but strong	• Bright green • Sword-shaped with sharp spines • 40 - 60 cm long, 1 - 4 cm wide
Flowers/Fruit	• 7 - 9 cm wide, **bright yellow** • 3 petals, 3 sepals with brown markings • Sepals much larger than petals	• 6 - 8 cm wide, **blue to purple with yellowish veins** • 3 petals, 3 sepals; sepals much larger than petals • Fruit capsules 2 - 3 cm long with flat seeds stacked inside	• **Tiny, male flowers on upper part of inflorescence, female flowers below**. Many small fruit, with many brown hairs	• Separate female and male flowers that occur on the same plant • **Spiny, ball-shaped fruit**
Rhizomes	• Pink, freely branching, 1 - 4 cm in diameter	• Thick rhizomes	• Spreading rhizomes	• Thick rhizomes

Biology and Life Cycle

Yellow iris is a perennial plant which reproduces both vegetatively and by seed. It has large, extensive underground rhizomes which cluster together and can form a root mass 3 - 4 meters in diameter. Rhizomes sprout new stems in the spring and can remain viable for up to 10 years and can survive up to 3 months of drought. Small rhizome fragments, as small as 2 cm, allow this plant to reproduce via fragmentation. Flowering occurs between April and July in Ontario, followed by production of beaked fruit capsules which contain over 100 seeds. Seeds are dispersed by water, being able to float for up to 2 months and germinate on moist, well-drained soil. Yellow iris can also tolerate anoxic (low dissolved oxygen, salinity, drastic changes in water levels and survive in winter temperatures (up to -25 °C).

Habitat

Yellow iris can occur as emergent vegetation in water up to 25 m deep but can also form dense mats of vegetation. It prefers fertile wetland habitats, including wet meadows, fens and swamps. It can also grow in shallow water along stream banks, lake shores, wet ditches, marshes, riverbanks, and pond edges. It can also be found growing in disturbed areas such as irrigation ditches and storm management. It prefers full sun, soils with high moisture and soils with acidic to neutral pH. While it can thrive on a variety of soils, it has high nitrogen requirements.

Pathways of Spread

Yellow Iris is commonly sold in the horticultural trade as an ornamental plant for water gardens, or for man-made or natural ponds on private property. It is valued for its showy yellow flowers and ability to persist in many environments. It may escape into nearby waterways as plant material is discarded or carried off by flooding during rain events. Many infestations originate from the intentional planting of yellow iris in gardens. The seeds and rhizomes of yellow iris can float for extended periods of time. It may also be accidentally spread through plant parts and possibly seeds that attach to boats, trailers or other equipment, such as fishing gear.

Distribution

In Ontario, yellow iris is found around the Greater Toronto Area including Toronto, Mississauga, Brampton and Markham. It occurs throughout southern Ontario including Chatham, London and Hamilton. It can be found in eastern Ontario in Peterborough, Ottawa, Kingston and Brockville and as far north as Sudbury. In Canada, Yellow Iris is found in British Columbia, Manitoba, Quebec, Newfoundland, Nova Scotia, New Brunswick and Prince Edward Island. It is widespread throughout most of the United States. For up-to-date distribution information, visit: EDDMapS www.eddmaps.org or iNaturalist www.inaturalist.org.

Impacts

Yellow Iris forms very dense stand of emergent vegetation or thick rhizome mats, dominating a variety of vegetation types within wetland and riparian habitats. These mats cut off sunlight, lowering plant biodiversity and displacing species needed by wildlife. Dense mats can also narrow waterways, alter hydrology and water quality and increase sedimentation. Yellow iris can also cause poisoning in animals if the rhizomes are eaten. It can cause skin blistering in humans if gloves are not worn when handling.

Control Measures

The key to successful control of yellow iris is to begin efforts in the early stages of growth, while populations are still manageable. It is very difficult to control once its thick rhizome mat is established. The target of control is to remove as much of the extensive rhizome system as possible. Control is only effective if it is repeated for several years, followed by monitoring to prevent regrowth

or new populations from re-establishing. Hand pulling and digging are often counterproductive as the rhizome fragments can regenerate from fragments. As such this method is more feasible for individual plants and smaller populations. When yellow iris occurs under at least 5 cm of standing water throughout the growing season, it can be managed using selective spading or cutting. Seed pods can be removed dry out (July - September) to prevent the spread of seeds. Large populations can be managed using benthic barriers. Control methods can disturb the soil and promote the growth of other undesirable species, therefore, it is important to consider restoration by planting native species. Appropriate clothing must be worn during removal of yellow iris, as sap in the leaves and rhizomes can cause skin irritation. There are currently no chemical or biological control options available for yellow iris in Canada.

See the section Applicable Legislation and Permitting Requirements (**page 8**) for more information on permitting requirements. Most of the control options described below will require permits or authorizations, in addition to adherence to rules prescribed under various provincial or federal legislation or regulations. Refer to section Prevent the Spread (p**age 6)** for details on how to report and prevent the spread the spread of aquatic invasive plants.

Manual Control

Hand Pulling and Digging:

Hand pulling or digging is an effective management technique for individual plants or small and isolated populations (< 1 m^2). Removing individual plants is important to prevent spread. When digging, ensure all plant parts are removed, especially the rhizomes. It may be difficult to remove the rhizomes of mature plants and may require the use of heavier tools such as saws. Digging must be done to a depth of 30 cm in 10 - 15 cm strips. Rhizome fragments as small as 2 cm that are left in the ground will grow new plants, contributing to the spread. It must be repeated 3 - 4 years. Pulling is not recommended for larger populations.

Mechanical Control

Selective Cutting in Water:

Cutting yellow iris below suitable water depths (at least 10 cm) can drown the plant. This works by cutting off the oxygen supply and trapping toxic gasses in the rhizomes. Maintaining the plants below the waterline prevents new shoots from developing as they cannot reach the surface to obtain oxygen. This method is suitable for small infestation that remain submerged throughout the growing season for at least one year. Remove all leaves and cut the plant below the waterline, ensuring that it will remain submerged at 10 cm below the waterline through the growing season. The base of the rhizome needs to be cut to prevent it from acting like a "snorkel" and provide oxygen to the rhizomes, preventing them from decaying. In conjunction with cutting, the shoreline portion should be treated with a benthic barrier.

Removing Seed Pods:

An effective technique to prevent seed development and dispersal is to remove seed pods. This method will not kill the plant or prevent them from spreading through its rhizomes. It is important to wear gloves to prevent exposure to the sap. Use garden clippers to remove seed pods into thick garbage bags. This is ideal for environmentally sensitive areas where digging would cause too much disturbance.

Cultural Control

Benthic Barriers:

Benthic barriers, which are also called bottom mats or bottom barriers, are covers placed on the bottom sediment of a waterbody over an invasive plant population. These covers prevent light penetration and kill rhizomes through trapping toxic compounds. The plant should be cut to its base (2 - 5 cm) prior to applying the benthic barrier. It is important to use heavy PVC pond liners (18 oz or PVC vinyl). Rhizomes can grow through tarps or plastic sheeting. Dig a trench and bury the liner into sediment. The benthic barrier should extend 20 cm beyond the edge of the infestation. If using multiple liners is required to cover the entire infestation, it is important that they overlap by at least 15 cm and be connected using 50 cm spikes with washers to have no open seams where the rhizomes can penetrate. Barriers need to be secured to the sediment using bricks or rocks.

Regulatory restrictions must also be considered. Benthic barriers are not permitted by Parks Canada for use in the Trent-Severn Waterway or the Rideau Canal. For projects on Provincial Crown land or shore lands, placement of these materials requires a work permit from MNR under the *Public Lands Act* as this control method does not fall under the provincial rules for removing invasive aquatic vegetation in Ontario without a work permit.

Tarping:

Tarping is applicable to yellow iris infestations that occur in on land. It involves covering the infestation with a material that is completely opaque where no sunlight can penetrate such as thick, non-woven landscape fabric, black plastic tarps, sheeting or cardboard. If the infestation also occurs in water, tarping should be used in conjunction with applying a benthic barrier.

Tarping should be done once in the spring and follow-up monitoring to remove growth beyond the tarp should be done throughout the growing season. Plants should be cut close to the ground before applying the tarp. Cover the entire infestation with the tarp and extend it at least 1 m beyond the edges of the infestation. Edges should be secured with rocks or bricks.

Biological Control

There are no biological controls available for yellow iris. The flea beetle *Aphthona nonstriata*, is undergoing host-specificity testing in South Africa and early results are promising.

Chemical Control

There are no aquatic herbicides registered in Canada that are available to control yellow iris.

See the Ontario Invasive Plant Council's Best Management Practices Guide on Yellow Iris **for more information this invasive plant and control methods.**

Yellow iris has erect leaves with bright yellow flowers.
Photo courtesy of Dawn Sucee.

Disposal of Aquatic Invasive Plants

Proper removal and disposal of invasive plants and plant parts is absolutely critical to preventing further spread or introductions, and is a requirement not only under the rules for the removal of invasive aquatic plants under the *Public Lands Act* (PLA), but also according to the Prevention and Response plans for the ISA prohibited species European Water Chestnut and Water Soldier. In addition, reasonable precautions to prevent the spread of restricted ISA species during the course of control activities is required in order to be exempt from depositing those species in Ontario.

Aquatic invasive vegetation must be disposed of on dry land, above the high-water mark, at a distance of at least 30 m from any body of water and in a manner that ensures no part of the plant will re-enter the body of water or enter into any other body of water.

In addition, if removed material is being transported to a disposal site it should be ensured that all plants and plant parts be secured in leaf bags and transported in a covered trailer, in closed containers, tarped bins or by another method that ensures the plants do not fall out of a vehicle during transport.

Depending on the amount of plant material removed, disposal methods can vary.

Exercise caution when composting. Most aquatic plants can be safely composted if in an area away from any body of water. If you must compost these types of plants, avoid doing so in backyard composters unless you solarize it first in black plastic bags and then compost the solarized material. Closely examine the plant before composting and avoid composting seeds.

If your municipality has a high-heat compost program, plants can be sent there. Ontario composting facilities are required to routinely monitor the compost process and meet strict, provincially regulated time-temperature parameters for pathogen kill. Consult your local municipality to determine if this is an appropriate course of action.

Do not dump. Many aquatic invasive plants are introduced to new areas through the dumping of aquarium contents or water garden plants into local waterbodies. It is illegal to introduce any aquatic plants or animals into a body of water where it is not native.

Depending on the amount of plant material removed, disposal methods can vary.

Photo courtesy of Diana Shermet, Central Lake Ontario Conservation Authority (CLOCA).

- **Small amounts:** Seal plant material in black plastic bags and leave in direct sunlight for one or more weeks (solarization) to allow the plants to dry out completely. These bags can be discarded in household garbage. Small amounts can also be put on land to dry and then be mulched, buried, composted or left to decompose. Disposal sites should be at least 30 m from the nearest waterbody, preferably in a flat, vegetated area, preventing fragments from inadvertently entering the water through runoff or other means.
- **Large amounts:** Contact your local municipality to determine if plant material can be disposed of in the landfill. Large amounts can also be burned where local bylaws permit this.

Tracking the Spread

While some invasive species are tracked carefully, there are many that are not been documented extensively throughout Ontario. There are gaps in our understanding of these species, their provincial distribution, and the scale of their invasion in many locations. Several reporting tools have been developed to assist the public and resource professionals in recording sightings and tracking the spread.

These include:

1. **EDDMapS:** An online reporting tool and **FREE** mobile application (iOS and Android) where users can report sightings, review distribution maps, and explore educational resources of invasive species. This tool, at www.eddmaps.org, is free to use.
2. **The Invading Species Hotline:** A toll-free telephone number **(1-800-563-7711)** administered by the Ontario Federation of Anglers and Hunters through the Invading Species Awareness Program where individuals can report sightings verbally. If you suspect you have encountered an aquatic invasive species, please take a photograph (preferably with the plant out of the water and including the leaves, stem, and flowers, if present), mark your location, and call the **Invading Species Hotline.**
3. **iNaturalist:** An online reporting tool (www.inaturalist.org) where you can report sightings of invasive species in Ontario by searching for the 'Invasive Species in Ontario' project.

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Glossary of Terms

Aerenchyma: type of plant tissue, which allows for the exchange of gases between the shoot and the root

Annual: a plant that completes its life cycle in one year – germinating from seed, flowering, setting seed, and drying in one growing season

Apex: a tip

Axillary: in an axil e.g. the angle between leaf and stem

Axis: central line along which lateral parts of the plant are arranged

Beak: a comparatively short and stout terminal appendage on a thickened organ like a seed or fruit

Biennial: requiring two years to complete its life cycle, usually involving vegetative growth in the first year and reproduction (flowering, fruiting) and senescence (death) in the second year

Biomass: the amount of vegetative material (leaves, stems, etc) produced by a plant

Bract: a specialized, reduced leaf associated with a flower or flower cluster

Branched: more than one stem

Bulbil: a bulb like vegetative structure produced by some plants that is capable of forming a new plant

Culm: a plant stem

Dichotomous(ly): forking in pairs

Dioecious: a condition where male or female flowers are on separate plants; compare to monoecious

Dissected: divided into many small segments

Elongate: considerably longer than wide

Emergent: partly submerged in water, partly above water surface

Entire: a continuous edge without teeth or lobes

Evergreen: a plant that maintains its leaves and sometimes continues to grow throughout the year

Floating-leaved: a plant that is rooted in the sediment and has leaves that float on the surface of the water; examples include Water Chestnut and waterlily

Fragmentation: a process whereby part of the plant is removed from the rest of the plant due to natural or mechanical means

Glume: one of a pair of bracts, found at the base of a grass spikelet, which do not subtend flowers

Herbaceous: a fleshy plant with little or no woody material

Hypoxic: oxygen depletion reduced in concentration to a point where it becomes detrimental to aquatic organisms

Inflorescence: a flower cluster; the arrangement of flowers on the axis

Internode: the part of the stem between two nodes

Ligule: collar-like appendage at the upper edge of a leaf sheath

Linear: very long and narrow, with parallel edges

Meristem: the part of the plant from which new growth originates; also called a bud

Midvein: the central vein of the leaf

Monoculture: a group of plants consisting solely of members of a single species

Monoecious: a condition where individual plants bear both male and female flowers on the same plant; compared to dioecious

Node: the place where a leaf or branch is attached to a stem

Oblong: shaped like a geometrical rectangle (other than a square)

Palmate(ly): lobes of leaf segments radiating from a common point

Pedicel: the stalk of a single flower in an inflorescence

Perennial: a plant that lives for more than two years

Perfect: describes a single flower that has both male (stamen) and female (pistil) reproductive organs

Petiole: a leaf stalk

Pinnate(ly): leaflets (or segments) arranged on two sides of an axis

Pistillate: a flower bearing female reproductive structures and lacking male reproductive structures

Propagation: the act of creating new plants through sexual or reproductive means

Propagules: vegetative or sexual structures with the ability to create new plants; examples include turions and tubers, fragments and seeds

Ramet: a new plantlet formed by vegetative means, often born on a runner or stolon

Rhizome: an underground stem, usually elongate

Rootstock: the roots, crown and rhizomes of the plant

Riparian: adjacent to a river or stream, including shores and floodplains

Rosette: a cluster of leaves or other organs radiating from a centre point

Stamen: the pollen-producing reproductive organ of a flower

Stipule: an appendage at the base of the leaf stalk, usually leaf-like